# ZX 81 BASIC BOOK

Robin Norman


Newnes Microcomputer Books

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**Newnes Technical Books**
is an imprint of the Butterworth Group
which has principal offices in
London, Boston, Durban, Singapore, Sydney, Toronto, Wellington

First published 1982
Reprinted 1982



**British Library Cataloguing in Publication Data**

Norman, Robin
ZX81 Basic Book
1. Sinclair ZX81 (Computers) — Programming
2. Basic (Computer program language)
I. Title
001.64'42 QA76.8.S/

ISBN 0-408 01178 5

Typeset by Tunbridge Wells Typesetting Services Limited
Printed in England by Butler & Tanner Ltd., Frome and London

# Preface

It's hard for a mere author to keep up with the microcomputer industry. In 1980 I wrote a book for new owners of the Sinclair ZX80, and simultaneously with the publication of that book, the latest Sinclair offering was announced — the ZX81. ZX80 was an incredible machine, but it did leave one saying, 'If only it would do this and this . . .'. Now nearly all these gaps have been well and truly filled by the Sinclair ZX81, which does nearly everything for less money!

The reception for our previous book was good enough to encourage Newnes and myself to press on with a new version for the ZX81. With so many new features available in ZX81 BASIC, it was obvious that most of the book would have to be rewritten. Nevertheless we have used the same layout, and made the same three assumptions about the reader of the book — who naturally may be 'she' or 'he':

1 He is a newcomer to computer programming (depending on experience, he can of course skip early sections of the book).
2 He has one particular microcomputer, the Sinclair ZX81, switched on, in front of him.
3 He wants to learn to use all the instructions in ZX81 BASIC, using a structured course with a steadily increasing tempo.

You cannot 'read' a book like this. Whatever you get out of it will be the result of a three-way interaction between you, this book, and the ZX81. And if you ever find yourself thinking, 'What would happen if . . .?', then for goodness sake try it! You won't break the ZX81 and you'll probably learn something.

A few acknowledgements — first to Betty Clare for typing difficult manuscripts so well. To Peter Chapman for helpful ideas, and to my family for still being patient. And finally to Clive Sinclair for lending

the hardware — one has to say that with the ZX81 he has 'done it again'. A marvellous little machine, admittedly a little low on memory (that's what the 16K RAM expansion is for), fine for beginners and yet able to hold its own with many machines costing much more.

Happy programming to you all! R.N.

# Contents

# List of Programs

# 1

# What do Computers Do?

Rather a philosophical chapter, this — come back to it later if you're in a hurry to get started!

## Machines Controlling Machines

Man is in many respects a poor match for other inhabitants of this planet. We have achieved our dominance on Earth because of our large brains, and the way in which we have used these to devise tools. These tools not only save labour, but they also allow us to do things that would be inconceivable without them.

At some stage in pre-History, we used our flint knife to cut notches on a stick — now we had two different kinds of tool:

(1) Tools to do mechanical work — helping our muscles.
(2) Tools to calculate and remember — helping our brain.

Luckily, we did not put these two kinds of tool into watertight compartments. Our best progress has been made since we combined the two and used the calculating tools to control the mechanical tools. It's been going on for a long time, as these examples will suggest.

Simple gauges to check that arrows are of a standard length and diameter.
Capstan lathes to allow intricate metal working to be done by unskilled people.
Electronically controlled robots to assemble car bodies with a minimum of human help.

Of course, it's electronics and the famous 'silicon chip' which has spread automatic control of machines so widely. They also bring social problems to be solved — how to share out the benefits fairly among us all — but that's another story.

## 'Pure' Calculating Machines

Since this group includes the Space Invader machine, I thought it best to put the word 'pure' in quotes! I use it to mean calculating machines which are not used for the direct control of any other machine. We've been using these for a good long time, for counting our money and possessions, for advancing our knowledge, and to amuse ourselves. Here again the silicon chip has brought about a revolution in reducing the size and price of these machines, until we can get a pocket calculator with pocket money and a microcomputer for a birthday present.

### *Dedicated or open-minded*

I want to distinguish two different kinds of electronic calculating machines:

(1) The dedicated machine which has a detailed set of instructions built in to make it do one particular job (e.g. Electronic Mastermind).
(2) The machine with an open mind — we can put in our own instructions to make it do all sorts of jobs — including playing a game of Mastermind
(e.g. The Sinclair ZX81).

Even the open-minded machines are dedicated to some extent. For instance, the ZX81 has a lot of instructions built-in so that it can understand one particular programming language — BASIC.

## Hardware and Software

There's a lot of jargon used in the computer business — it's a shorthand which helps people on the inside, but forms a barrier to people on the outside. I'll try to keep it to a minimum, and I'll help you by including a glossary of new words (and old words with new meanings) at the end of this book.

Hardware means all the physical parts of the computer — the ZX81, TV set and cassette recorder.

Software means all the programs and instruction books needed to make the computer work — the ZX81 operating manual, this book, the permanent programs put into the ZX81 by its designers, and the programs that you write.

Having gone from the general to the particular, we'll move on to see how we can communicate with a computer.

# 2

# Talking to Computers

## Computer Languages

Humans have ten fingers, and so have got used to counting in the *decimal* system using the digits 0 to 9. Computers, on the other hand, work with *binary numbers.* A binary digit (bit for short) can only have the values 0 or 1, and the computer is just about bright enough to tell the difference between them!

One can write programs in binary numbers (in the early days of computers this was the only way), but humans find binary numbers clumsy to handle and hard to recognise. A better way is to write programs in a *low-level language,* using machine code based on hexadecimal (base 16) numbers, which are easily converted to binary. Machine code programs are fast to run and economical on computer memory, but they are no way for beginners to learn programming. Most people converse with computers in a *high-level language,* which uses decimal numbers and sets of recognisable English words. Some common high-level languages are:

| | |
|---|---|
| FORTRAN | FORmula TRANslation, mainly for science and engineering |
| COBOL | COmmercial Business Oriented Language |
| BASIC | Beginners All-purpose Symbolic Instruction Code |

New languages appear from time to time, having various advantages claimed for them. BASIC is probably the most widely used language in today's generation of microcomputers.

The computer cannot understand these high-level languages on its own, and so programs are built in to translate them via machine code into binary numbers.

## Computer Memories

The memories of a computer consist of a large number of 'boxes' or 'pigeon-holes', each containing an 8-bit binary number (called a *byte*). Memory size is specified in terms of K, where 1K is a memory with a capacity of 1024 bytes. There are two kinds of memory in a microcomputer like the ZX81:

*Read Only Memory* (ROM)

This contains the program needed to run the computer and to translate the BASIC instructions into binary code. ROM is permanent and so is not lost when the computer is switched off. The ZX81 uses BASIC in 8K of ROM.

*Random Access Memory* (RAM)

This contains all the data and programs which you put in. It is not permanent, and if you switch off for a moment, the RAM contents are lost. Your ZX81 has 1K of RAM available, but you can increase this to 16K by plugging in the 16K RAM pack.

## Input and Output

We need to be able to put data and instructions into the computer memory, and the ZX81 provides us with a scaled-down version of a standard typewriter keyboard for this purpose. We also have to provide the means for the ZX81 to display its results, and for us to see what we are typing in — an ordinary UHF TV set is used for this.

If we want a permanent record of a program, or of the ZX81 output, we can use a printer which is connected to the ZX81. ZX81 uses a non-standard character set, and the only suitable printer is Sinclair's own.

## Long Term Storage

We've already seen that when you switch off the ZX81, all the contents of the RAM are lost — possibly a precious program that you've taken hours to write! Even if it was recorded on the printer you would have to type it out again. We need long term or *back-up storage*, in which to keep our programs and data permanently. ZX81 uses a standard tape or cassette recorder, and programs and data can be saved on tape, kept as long as you like, and then loaded back into the ZX81.

## Looking Into the Future

This is the crystal-ball department, a list of the features I should like in my own personal computer in the future:

(1) Greater agreement on standards, so that programs become more interchangeable and computers can talk to each other more easily.
(2) Communication with the computer by voice, both for input and output.
(3) Cheap printed output — preferably in the form of an electronic typewriter which doubles as a printer.
(4) Cheap, unlimited, permanent memory for back-up storage.
(5) High-definition output in colour, comparable with TV standards.
(6) A large range of cheap software — programs for business, home, learning and leisure — in simple plug-in form.
(7) Connection to large central computers, probably via the TV network, to give access to virtually unlimited information on any chosen subject.

# 3

# Programming in BASIC

BASIC is one of the most widely used high-level languages, especially for the present generation of microcomputers. There are many different versions of BASIC, in the same way as there are different dialects of English. But do not despair! All versions of BASIC are easily recognisable as coming from the same original source (BASIC was developed at Dartmouth College, New Hampshire, USA), and when you have learnt one form of BASIC you can quickly transfer to another form on another computer. Sinclair ZX81 BASIC in 8K ROM is a fairly complete version with a few non-standard features, and in many ways it is an excellent BASIC for beginners to learn.

## The First Computer Program?

Let's use a light-hearted example for our first look at programming. Walt Disney's *Fantasia* is revived from time to time, and one of my favourite parts is *The Sorcerer's Apprentice* by Dukas. Mickey Mouse is the apprentice who is left on his own with the boring job of filling a great tank with water from the well. Mickey is a bright lad, and he decides to program one of the kitchen brooms to do the work, while he has a crafty snooze.

In writing a computer program it's very important to get the instructions in the right order, and so every one is given a number. Mickey's first attempt could have been like this:

1 Pick up bucket and go to well
2 Fill bucket with water
3 Carry bucket to water tank
4 Empty bucket into tank

So far, so good. One bucketful of water has been shifted! Mickey could repeat the same instructions over and over again, numbering them 5, 6, 7, 8 and 9, 10, 11, 12 and so on. Not a bit! He has read Chapter 12 in the spell book, and all he does is to add one more instruction:

5 GO TO 1

and now he has made a *program loop.* The broom follows the program exactly, and goes happily backwards and forwards, filling and emptying buckets, while Mickey nods off . . .

* * * * *

. . . until he wakes with a start some time later to find water lapping round his knees. You've guessed it — he forgot to tell the broom when to stop! Panic — he chops the broom into sixteen pieces, but each of these gets up and carries on with the work. Luckily the sorcerer returns home just in time. He is skilled in the arts of programming brooms, and knows that every loop must include a 'get out' test, or it will go on for ever. This vital step always contains the magic word 'IF', and we call it a conditional jump.

With its IF statement, and a little renumbering, the final program looks like this:

1 Pick up bucket and go to well
2 Fill bucket with water
3 Carry bucket to water tank
4 Empty bucket into tank
5 IF water tank is not full THEN GO TO 1
6 Report 'Tank Full'
7 Stop

The IF statement has to be inside the loop, so that every time the broom goes round the loop, it can check whether the tank is full, and take action accordingly.

Well, that was childish stuff, but it did raise four points which will be important when we come to write real programs for the ZX81.

(1) A BASIC program is made up of a series of *instructions.*
(2) The instructions are all *numbered* so that the computer can carry them out in the order it is told to.
(3) You can make a computer do part of a program over and over again by using a GO TO instruction. We call this a *loop.*
(4) A loop must contain a *conditional jump,* which will stop the computer or send it out of the loop when the condition is obeyed. The magic word is 'IF'!

# 4

# The Hardware

Before connecting up the hardware and switching on, you had better consult Chapter 1 in your manual, *ZX81 Basic Programming*. The three vital parts are the ZX81 itself, its power supply and a UHF television set (black and white sets seem to work best). The ZX81 will happily work away without a TV attached, but you need to see what you are telling it to do, and it needs to tell you what it has done! Join up the three units as described in your manual. Turn on the power, switch on and then tune the TV. When correctly tuned (about 36 on the tuning knob, if numbered) you see a white K in a black square at the bottom left — we call this the [K] cursor.

## The ZX81 Keyboard

It's worth while taking trouble to get used to your ZX81 keyboard — it's been carefully designed to make each key do as much work as possible. These are the various items that the keys will produce on the screen:

(1) The set of keywords

These are the words in small white print above each letter key — they are the instructions which tell the ZX81 what to do. When the [K] cursor is showing and you press a letter key, you put the corresponding keyword on the screen — try any *one* now. I just pressed Y, which put the keyword **RETURN** on the screen and changed the [K] cursor to [L]. Some of you are asking the obvious question — 'How do I choose between a letter and a keyword?' The answer is simple — you don't! The ZX81 knows when keywords or letters are needed, and puts the correct cursor on the screen as required.

It's a help to remember that many keywords are placed above or near their initial letter, to help you to find them quickly. In this book, as in your manual, all words produced by a single keystroke are printed in bold type, for example:

**PRINT** **ABS** **TO**

(2) The set of letters

You can type any letter on the screen (or space or full stop) by pressing the corresponding key while the [L] cursor is showing. Try some now, and notice how the [L] moves ahead of your typing all the time. The next character you type is always printed at the current position of the cursor.

(3) The set of numbers

You can type these just like letters, except that numbers are printed regardless of whether the [K] or [L] cursor is showing, and they don't change the cursor from [K] to [L]. Notice the zero, Ø, which must not be confused with letter O. Be careful also with number 1 and letter I.

(4) The set of upper case characters

If you hold down **SHIFT** (bottom left of the keyboard) and press almost any letter or number key, you will print one of a whole collection of words, punctuation marks and maths symbols, printed in red on the top part of each key. The exceptions are **SHIFT** 1 and **SHIFT** 5 to Ø which print nothing on the screen — we'll see what they do later.

Five of the upper case characters (**STOP, LPRINT, SLOW, FAST, LLIST**) are keywords for use with the [K] cursor, the rest for the [L] cursor only.

(5) The set of functions

These are printed in small white letters underneath each letter key. Hold down **SHIFT** while the [L] cursor is showing and press the key **FUNCTION/NEWLINE** on the far right. You will see the cursor change from [L] to [F], and if you now press any letter key (other than V) you will put the corresponding function on the screen. Functions are usually needed one at a time, so the cursor automatically changes back to [L].

(6) The set of graphics characters

Press the **GRAPHICS** key (**SHIFT** 9) while the [L] cursor is showing, and you will see the cursor change to [G] (it will stay like that until you press **GRAPHICS** again). Now you can experiment with a whole lot of special effects.

Press any letter or number key, and you will get its *inverse* (white on black), useful for emphasis. Hold down **SHIFT**, and press one of the block of 20 keys on the left of the keyboard, and you will get one of the special black/white/grey graphics blocks. Later on we'll be using these for drawing pictures and graphs. **SHIFT** with any other key will give you the inverse of the corresponding upper case character.

Now we know how to type any of the characters on the screen, so we can go on to write a program, but first we must clear the screen of rubbish. A quick way is to press **EDIT** (**SHIFT** 1), which empties the screen, leaving the K cursor. We get the same effect by unplugging the power jack plug, but remember for the future that this loses all the programs and data in the ZX81 — it's a last resort!

## We Learnt These in Chapter 4

Setting up the ZX81.
Sets of characters available from the keyboard.

# 5

# Your First Program

## Clearing Out Old Programs

You must get rid of any old programs from the ZX81 memory before you type in a new one. Right, I know there's nothing there, but let's practise anyway. At the end of the last chapter we set the cursor to [K], so all we have to do is to press key A and the keyword **NEW** appears on the screen. Now we need to pass this to the ZX81 for action, so we press **NEWLINE** on the far right of the keyboard. **NEW** vanishes from the screen — the ZX81 has now obeyed the command 'clear out any old program and get ready for a new one' — and [K] reappears.

## Commands and Statements

'When I use a word', said Humpty Dumpty, 'it means just what I choose it to mean'. We just used the instructions **NEW** and **NEWLINE**, and I am calling these *commands*. Commands are not part of a program, they are orders from outside the program which are obeyed once and then forgotten. Nearly all the keywords, plus upper case **EDIT, LPRINT, SLOW, FAST** and **LLIST**, are accepted as commands by the ZX81. **INPUT** gives an error, and **FOR, NEXT, PAUSE, SCROLL** are not useful.

Statements, on the other hand, are instructions included in numbered program lines which form part of a program. They are remembered by the ZX81 and obeyed every time the program is run. Any keyword (except **CONT**) can be used as a statement, as well as upper case **STOP, LPRINT, SLOW, FAST, LLIST**.

## Writing a Program

And about time! We saw in Chapter 3 that all BASIC program lines must be numbered, so type a line number, say '1Ø'. The cursor is still [K], because the first item after a line number *must* be a keyword, so now press key 'P'. You now have:

1Ø **PRINT** [L]

on the screen, so continue by typing:

1Ø **PRINT** "RULE 1 IN BASIC [L]

and then press **NEWLINE** to enter it into the ZX81 memory. What happened? Yes, yet another cursor [S] appeared! This marks a *syntax error*, something wrong with the line which prevents it from being entered. At the moment it is saying, 'Quotes come in pairs!', so add the missing quote at the end and press **NEWLINE** again. This time your line 1Ø pops up to the top of the screen, it has gone into memory, and the [K] cursor reappears at the bottom, ready for the next program line.

No more lines for the present, we'll run the program as it stands. Press 'R' to put the command **RUN** on the screen, and you know by now that the next key to press is **NEWLINE**.

When the cheering has died down, look carefully at what happened. The words and spaces inside your quotes have all been printed according to plan, while the line number, cursors and quotes have been left out — they were there to tell the ZX81 what to do. What we did in line 1Ø was to **PRINT** a *literal string* on the screen. Literal strings are enclosed by quotes, and may contain *anything* from the keyboard except a **SHIFT** P quote (use **SHIFT** Q for a picture of a quote if you need one). At the bottom of the screen is Ø/1Ø, the ZX81's *report code*, which is saying 'Program ran without problems and ended with line 1Ø'. Your numbered program line is still in memory, where it will stay till you clear it out, or type **NEW**, or switch off. You can see it again if you wish by pressing **NEWLINE**.

Hidden under the report code is a [K] cursor, ready for your next program line. Let's go on to the next chapter and type some more.

## We Learnt These in Chapter 5

*Commands*

**NEW** to clear out old programs.

**NEWLINE** to pass commands to the ZX81 and to enter numbered lines into a program.

**RUN** to make the ZX81 run your programs and carry out the instructions in them.

*Statements*

**PRINT** to print literal strings on the screen.

*Anything else*

Commands and statements.
The cursors.
Syntax errors.
Report codes.

# 6

# Tidy up Your Programs!

## A Second Line

Press **NEWLINE** if necessary to display the current program at the top of the screen, then type this second line exactly as printed:

2Ø **PRINT** "EVERY LINE NEEDS A NUMBERS" [L]

Sorry — some bad spelling there! Don't panic, hold down **SHIFT** and press **RUBOUT** twice. You will see the [L] cursor move back two spaces, rubbing out the quote and the offending S. Now retype the quote and press **NEWLINE**, sending line 2Ø up to join the rest of the program. Run the program as before, and you'll get this on the screen:

RULE 1 IN BASIC
EVERY LINE NEEDS A NUMBER

plus the usual report code Ø/2Ø.

So far I've carefully printed in the cursor wherever it occurred in a program line. Now I'll leave it out unless there is a special reason.

## Tidying Up

The result will look neater if we put a space between the two lines of output. Try this — type:

15 **PRINT**

and enter it by pressing **NEWLINE**. What on earth are we trying to do? **PRINT** what? Well, run the program and see what happens. It worked, didn't it! When the ZX81 comes to a **PRINT** statement it prints what it is told to. In line 15 it was told to print nothing — nothing was what it printed!

Finally we'll add a comment to say what the program is about. Type the following:

5 **REM** ** MY FIRST PROGRAM

The **REM** statement is saying, 'Ignore the rest of this line, it is only a programmer's remark'. The ** are simply added to make the **REM** lines show up better.

## Numbering and Listing

Most computers have to be asked for a list of lines in a program, but ZX81 gives you a list as soon as you press **NEWLINE** or when you add a line to your program. I'm sure you've noticed that the ZX81 has sorted the lines into numerical order, although we typed 10, 20, 15, 5. I expect you have also realised why we left gaps between the line numbers. Yes, it makes it easy to insert lines later on, as we did with lines 15 and 5. ZX81 does not care what the line numbers are, it is only interested in the *order*. There is a choice of line numbers from 1 to 9999, so there's no shortage.

## Getting Rid of Whole Program Lines

Let's suppose we want to erase line 5 to save memory space — often the ultimate fate of **REM** lines. Simply type the line number 5 and press **NEWLINE**. Line 5 has gone, just like that! Alternatively you can completely change a line by typing its line number, then the new version, and then pressing **NEWLINE**. You can do this as often as you like, ZX81 will always delete an old line and replace it with the new one.

Now for a couple of exercises to practise what we have learnt in the last two chapters.

*Exercise 6.1. Line changing*

Delete lines 15 and 2Ø of the current program, then change line 1Ø to make the ZX81 print the message:

THREE LINES GONE, ONE LEFT

*Exercise 6.2. Your address*

Delete the old program with a single keyword (remember which one?). Write a program to print your name and address as though on an envelope. Just to show it can be done, leave gaps of 1ØØØ between your line numbers.

## We Learnt These in Chapter 6

*Statements*

**PRINT** to make a line space.
**REM** for a remark, ignored by the ZX81.

*Anything else*

**RUBOUT** to delete characters one at a time in a line you are writing.
Automatic listing by pressing **NEWLINE**.
Line numbering with gaps for later additions.
Deleting and changing existing lines.

# 7

# Sums? No Problem!

Until now I have been reminding you to press **NEWLINE** to pass commands and program lines from the bottom of the screen to the ZX81. From now on it's up to you!

## Keywords in Command Mode

We have used **PRINT** as a statement in program lines, but we saw in Chapter 5 that most keywords could also be used as commands. Try typing:

**PRINT** "THIS IS A ONE-OFF COMMAND"

The ZX81 obeys the command *once*, but it is then forgotten and cannot be obeyed again. The report code Ø/Ø shows that there was no line number.

## Numbers and Expressions

We can make the ZX81 print *numbers* in the same way as we have printed strings, except that quotes must not be used. Try a few like:

| | |
|---|---|
| **PRINT** 99 | **PRINT** 3.74 |
| **PRINT** Ø.Ø75 | **PRINT** .625 |

The full stop doubles as a decimal point, and leading Øs on the left of the decimal point need not be included.

Expressions consist of numbers and operators, for example 5+3. If we ask the ZX81 to print an expression, it will helpfully work out the answer and print that. Type in:

**PRINT** 5+3

The answer 8 appears at the top of the screen — we have used the ZX81 like a pocket calculator, but with the advantage that we can see the whole expression, and if necessary correct it, before it is worked out.

## Operators and Priority

We all remember the four standard maths operators. You will find – and + easily at **SHIFT** J and **SHIFT** K. Instead of x or 'multiplied by' we use * (**SHIFT** B), and for ÷ or 'divided by' we use / (**SHIFT** V) — this is standard computer practice. In addition we have ** (**SHIFT** H) which means 'raised to the power of':

2**3 = $2^3 = 2 \times 2 \times 2 = 8$

Try typing more simple expressions, each made of a pair of numbers with an operator:

**PRINT** 25–17 **PRINT** 7–12 **PRINT** 9*11
**PRINT** 63/9 **PRINT** 125/48

Notice that the ZX81 happily copes with negative numbers and decimals. If you type:

**PRINT** 2/3 and **PRINT** 1/3

you will find the answer printed to 8 decimal places, the last place being rounded up or down as usual.

What happens with longer expressions like:

2+3*4?

If we are doing sums like these on paper, we have to follow a standard *order of operations.* ZX81 and most computers do the same.

| | | |
|---|---|---|
| Highest priority | ** | (to the power of) |
| ↓ | * and / | (times and divided by) |
| Lowest priority | + and – | (plus and minus) |

So the expression above is worked out in two stages:

(1) 3 * 4 = 12
(2) 2 + 12 = 14 (answer)

Try these expressions, and make up more of your own:

**PRINT** 7*2–5 **PRINT** 9–12/6
**PRINT** 3**3+5 **PRINT** 38–5**2

Make sure you are getting the answers you expect!

## Using Brackets

If we want to tell the ZX81 to *change* its priority rules, we can do so by using brackets. The ZX81 will follow standard mathematical rules and work out the part of the expression inside brackets first. Compare these two expressions:

| | | | |
|---|---|---|---|
| **PRINT** | 2+ 3* 4 | **PRINT** | (2+3) * 4 |
| (1) | $3 \times 4 = 12$ | (1) | $2+3 = 5$ |
| (2) | $2+12=14$ | (2) | $5 \times 4 = 20$ |

Check that the ZX81 gives the right answers. You can use as many brackets as you like, *in pairs*, either separately or nested inside each other. When the ZX81 meets nested brackets, it starts with the expression in the inside pair(s) and then works its way outwards. Don't hesitate to use extra (unnecessary) pairs of brackets if it makes an expression easier for *you* to understand.

*Exercise 7.1. Expressions with brackets*

Work out the answers to these expressions, then check them with the ZX81.

```
((7-5)*(30/12))**3
(((6*8)-(23-11))/(5+7))**2
```

## Scientific Notation

Type these commands and look carefully at the answers:

**PRINT** .ØØØØ7
**PRINT** 7/1Ø**5
**PRINT** 7ØØØØØØØØØØØØ (12 Øs)
**PRINT** 7*1Ø**12

and now these:

**PRINT** .ØØØØØ7
**PRINT** 7/1Ø**6
**PRINT** 7ØØØØØØØØØØØØØ (13 Øs)
**PRINT** 7*1Ø**13

When numbers get too big or too small, ZX81 prints them in scientific notation:

7E+13 is the same as 7*10**13 or $7 \times 10^{13}$
7E−6 is the same as 7/10**6 or $7/10^6$ or $7 \times 10^{-6}$

Many calculators use just the same method to accommodate small and large numbers.

If we wish, we can use scientific notation for the numbers we pass to the ZX81. Type:

**PRINT** 7E–5
**PRINT** 7E–6

and so on. The ZX81 always changes to normal decimal notation if it has room.

## We Learnt These in Chapter 7

*Commands*

**PRINT** to print strings, numbers or the answers to expressions.

*Anything Else*

Mathematical operators and priority.
Brackets to change priority.
Scientific notation.

# 8

# Vital Variables

We have seen how to command the ZX81 to print numbers, or the answers to expressions, on the screen. We can do the same in a program, but it is not particularly useful, and we have a far more powerful statement available, **LET**.

## Defining a Variable with LET

Clear the ZX81 with **NEW**, and then type this line:

```
1Ø  LET X=5
```

Run it — there's no output apart from the Ø/1Ø 'O.K.' message — what have we done this time? Well, in long-winded English we have said, 'Label a memory box X and put 5 in it'. In other words we have defined the variable X as having the value 5.

Now we can do all sorts of things with the contents of X. We can print it:

```
2Ø  PRINT X (and RUN)
```

We can use it in expressions:

```
3Ø  PRINT 1ØØ*X
4Ø  PRINT X**3
```

Note that, although we have used the contents of box X in lines 2Ø, 3Ø, 4Ø, the 5 is still there. Check this by adding:

```
5Ø  PRINT X
```

The original 5 *is* still there, but we *can* change it if we wish.

```
6Ø  LET X=999
7Ø  PRINT X
```

Line 6Ø said, 'Throw out the contents of box X and insert 999'. We can change the value of a variable as often as we like — that's why it's called a variable.

## Naming Variables

The number of variables we can use in a program is limited only by memory space, but they must all have different names! ZX81 offers the widest choice of names in town, you just have to follow these rules:

(1) Variable names *must* start with a letter, not a number.
(2) Variable names *may* contain any mixture of letters and numbers, but not spaces (ignored) or any other characters (illegal).

We generally use short names to save memory and effort, often choosing mnemonics (memory joggers) of the contents — T for total, W for weight, and so on. Try out your own names for variables, using **LET** as a command if you wish, and see what happens when you break the rules above.

## More Advanced LET Statements

Our statement has the general form:

**LET** variable name = . . .

What can we put on the right of the = sign? Here are some examples, the first we have seen already.

(1) A number:

**LET** B=75

(2) An expression using numbers:

**LET** C=23*45

(3) An expression using other variables, with or without numbers:

**LET** A=C  **LET** V=B**3

Important — you can only put a variable on the right if it has already been defined. ZX81 refuses to work with variables it does not know about.

(4) An expression using the same variable as the one on the left:

**LET** B=B+1Ø  **LET** A=A*X

Algebra was never like this! Remember that these are not equations. We are saying things like, 'Take out the contents of box B, add 1Ø to it and put this new value back into box B'.

## How We Use Variables

If we know the radius (R) of a circle, we can use these well known equations to work out the diameter (D), circumference (C) and area (A).

$D=2R$
$C=\pi D$
$A=\pi R^2$

(let's take $\pi$ as 3.14 for now).

We can put all this into a simple program. First we define R, the radius of the circle in cm:

```
1Ø  LET R=5
```

Next we calculate the three unknowns and use them to define variables.

```
2Ø  LET D=2*R
3Ø  LET C=3.14*D
4Ø  LET A=R**2*3.14
```

Finally we can print the results:

```
5Ø  PRINT R
6Ø  PRINT D
7Ø  PRINT C
8Ø  PRINT A
```

Run the program and check the results with a pocket calculator. We can make the results less anonymous by printing titles:

```
45  PRINT "RADIUS GIVEN= "
55  PRINT "DIAMETER= "
65  PRINT "CIRCUMFERENCE="
75  PRINT "AREA= "
```

You can change to any other given radius by rewriting line 1Ø. Not a bad little program, but what a messy print out! We'll tidy it up in the next chapter.

*Exercise 8.1. Money changing*

Today's exchange rate is U.S.A. $1.90 for £1. Write a program to print out the number of $ you get for £75, and how many £ you must hand over to get $250.

*Exercise 8.2. Parachuting*

One of the Falcons team jumps from his plane at 3 000 metres. The distance he drops (S) is given by $S=AT^2/2$ where A is the acceleration due to gravity = 9.8 m/s/s and T is the time in seconds after jumping (air resistance ignored). Write a program to calculate his height after 10 seconds. If he must pull the rip-cord 500 metres above the ground, use your program to find roughly how many seconds his free fall will last.

## We Learnt These in Chapter 8

*Statements*

**LET** to define a variable.
**PRINT** to print the current value of a variable.

*Anything Else*

Rules for naming variables.
Various ways of using variables.

# 9

# A Little Punctuation Works Wonders

So far we have been using **PRINT** to print items on successive lines of the screen. We often want to put several items on the same line — try this short program:

```
10  PRINT "AREA OF A SQUARE"
20  PRINT
30  LET S=4
40  PRINT "SIDE= " ; S ; " CM"
```

Run it, and look carefully at the result of line 40. The vital parts are the semi-colons which are saying, 'Don't move to a new line, print the next item immediately after this'. You can use semi-colons as here, in between **PRINT** items on a line, or you can put one at the end of a **PRINT** line — the next **PRINT** item will always be printed right after the last. Notice that we wanted a space between S and CM, so we had to include one inside the quotes.

Now change the program like this:

```
35  LET A=S*S
40  PRINT "SIDE= " ; S ; " CM", "AREA= " ; A ; " SQ CM"
```

Another useful bit of punctuation, the comma. Each line is divided into two halves, and the comma says, 'Move to the beginning of the next half and print the next item there'. You can use commas in clusters if you like, each one moves the print position to the beginning of the next half line.

We already know that full stop has the function of a decimal point. Apart from this the rest of the punctuation (. : ?) can be used in literal strings but has no other special use.

## Tabulation

How many characters can you pack into one line of the screen? Try this:

```
20 PRINT "0123456789012 34 . . .
```

After a while your numbers run onto the next line, but remember that your 2∅ **PRINT** " takes up some space. Stop typing numbers when the [L] is exactly beneath the first ∅, add your final quotes and press **NEWLINE**. Now if you run the program you will get a complete line of 32 numbers (to check up, type another line with one more number). We can complete the line numbering by printing the tens, starting with ten spaces:

```
10 PRINT "          1111111111222222222233"
```

Now check the comma print position by typing:

```
30 PRINT
40 PRINT "FIRST HALF","SECOND HALF"
```

Now change and extend your program like this (remember that **TAB** is one of the set of functions):

```
40 PRINT "ONE"
50 PRINT TAB 7;"TWO"
60 PRINT TAB 15;"BUCKLE"
70 PRINT TAB 23;"MY SHOE"
```

It's pretty obvious what's happening. **TAB** n; moves the print position to number n and the next item is printed there. You must follow **TAB** n with ; ( , is possible but not usually sensible).

You often need to print several **TAB** items on the same line. No trouble — simply put in more semi-colons to stop the ZX81 moving to the next line. Here is a bank statement heading, to replace your nursery rhyme:

```
40 PRINT TAB 8;"BANK STATEMENT"
50 PRINT
60 PRINT
70 PRINT "DATE"; TAB 6; "DEBIT"; TAB 14; "CREDIT"; TAB
   24; "BALANCE"
```

We can print numbers, expressions or variables at **TAB** positions, in just the same way as we have printed literal strings. Here are some more advanced rules about **TAB** — they will come in useful later on.

(1) We do not need to use a number after **TAB**, we can use a

variable (previously defined), or an expression containing numbers and variables.

(2) If the number after **TAB** is a decimal, it will be rounded to the nearest whole number (7.5 rounded to 8).

(3) If the number after **TAB** is more than 31, it will be divided by 32 and the remainder used as the **TAB** number.

*Exercise 9.1. Circles*

Now go back to Chapter 8 and retype the last program there to give a print out like this:

```
   VITAL STATISTICS OF A CIRCLE
IF THE RADIUS IS 5 CM
DIAM=10 CM   CIRCUMF=31.4 CM
        AREA=78.5 SQ CM
```

When you have written the program, keep it to use in the next chapter.

## We Learnt These in Chapter 9

; , and **TAB** to vary the **PRINT** position on a line of the screen.

# 10

# Anyone can Make a Mistake!

So far we have seen two ways of correcting mistakes in a program. You can use **RUBOUT** in the line you are currently typing, or you can delete or replace an existing line by typing its line number plus the new version.

If we need to change a long line already entered into the program, the first method will not work, and the second takes a long time. The answer is to **EDIT** the line.

## The Current Line Pointer

Let's look at our program first. I am going to edit my version of the Circles program (Exercise 9.1 in Chapter 9). You could type my answer out yourself, or try editing your own version.

If you look at the program on the screen, you will find that one of the line numbers has a cursor ⊵ beside it — the current line pointer or program cursor. Unless you have moved it, it will be at the last line you typed in. The first job is to move the current line pointer to the line you want to edit:

(1) If it has not far to move, you can use ⇧ (**SHIFT** 7) or ⇩ (**SHIFT** 6) to push it up or down, line by line.
(2) To move it to the beginning of the program, type **LIST** and **NEWLINE**. The pointer, apparently vanished, has gone to an imaginary line Ø, and can be brought down with ⇩.
(3) To move it anywhere else, type **LIST** line number. Part of the program will be displayed, starting at that line number, with the point right there.

Practise moving your pointer up and down your program, using these three methods.

## Editing a Line

I want to edit my current line 9Ø:

9Ø **PRINT** "DIAM= ";D;" CM", "CIRCUMF= ";C;" CM"

by deleting all reference to diameter, and printing circumference in full at **TAB** 3.

First I put the current line pointer on line 9Ø and press **EDIT** (**SHIFT** 1). Line 9Ø is immediately printed in full at the bottom of the screen, with the [K] cursor following the number 9Ø. Now I can move the [K] cursor backwards or forwards along the line using ⇦ (**SHIFT** 5) or ⇨ (**SHIFT** 8), without changing the contents of the line. Try it, press   repeatedly and see the cursor skip along the line, changing to [L] as it passes **PRINT**. Stop it when it has just passed the comma in the middle of the line, then use **RUBOUT** to remove everything back to the first quote. You now have:

9Ø **PRINT** [L] "CIRCUMF= ";C;" CM"

Type in **TAB** 3; and then move the cursor along to just after CIRCUMF and type in the missing ERENCE.

If you mess up your editing, you can always press **EDIT** again and bring down the original version of the line.

Assuming that you are happy with the edited version:

9Ø **PRINT TAB** 3;"CIRCUMFERENCE= ";C;" CM"

press **NEWLINE**, and it immediately appears in its right place in the program, the old version disappearing for ever.

## Renumbering Lines

We'll renumber line 9Ø and make it line 1Ø5 — no trouble with the ZX81. Press **EDIT** to bring the line down for editing, and then press **RUBOUT** twice to remove the 9Ø. Type in the new number 1Ø5 and press **NEWLINE** to put line 1Ø5 into the program. Old line 9Ø is still there — you'll have to type 9Ø **NEWLINE** to get rid of this.

## Some Final Points

Remember that you can also use the arrows to edit a line you are writing for the first time.

If you write a long program, you will not be able to see the whole of it on the screen. The ZX81 will do its best to show you the bit you are currently working on. Otherwise you can type **LIST** n to display line n plus as many following lines as there is room for.

When your ZX81 memory is nearly full, you will find that **EDIT** has no effect, especially with long program lines. The remedy is to type **CLS** and **NEWLINE**. This clears the screen and **EDIT** will now bring the current line down for editing.

## We Learnt These in Chapter 10

*Commands*

**EDIT** to change a line which has already been entered in your program.
**LIST, LIST** n to see different parts of a long program.

*Anything Else*

The current line pointer and how to move it up and down.
How to move the line cursor.
Renumbering lines.

# 11

# Strictly Functional

The functions are all to be seen under the letter keys — together with a few oddments that are not functions. Don't worry if you don't recognise some of the maths functions in this chapter, just steam on to the useful number-chopping functions at the end.

A function of a number is an instruction to carry out some operation on that number and produce the answer. The number to be operated on — it can equally well be an expression or a variable — is sometimes called the 'argument' of the function. Try typing these commands:

**PRINT SQR** 81
**LET** A=25 and then **PRINT SQR** A
**PRINT SQR** 2
**PRINT SQR** (A*9)

I expect you have recognised *SQR* as your old friend the square root — a number which when multiplied by itself gives the number you started with. Notice that in the last example we wanted the square root of an *expression*, so we had to put the expression in brackets. A function always operates on the number or variable immediately following it, unless there are brackets to tell it otherwise. Put another way, a function has a *higher priority* than any of the maths operators.

We can use more than one function together — in this case they are carried out one by one from right to left. For example:

**PRINT LN SQR** 16

gives us the natural logarithm (to base e) of the square root of 16. We only have natural logs available on ZX81, by the way, with natural antilog alongside (**EXP** or $e^x$).

## The Trig Functions

Take any circle, divide the circumference by the diameter, and you get a constant a little over 3 which we call PI (Greek letter $\pi$). For a more accurate version type:

**PRINT PI** ($\pi$ on the keyboard)

The trig functions are all functions of *angles*, and ZX81 needs the angles to be expressed in *radians*. We can easily convert degrees to radians, remembering that:

PI radians = 180°

Try this little trig table program if you are interested:

```
1Ø  LET XD=3Ø
2Ø  REM XD IS ANGLE IN DEGREES
3Ø  LET XR=XD*PI/18Ø
4Ø  REM XR IS NOW IN RADIANS
5Ø  PRINT XD;" DEGREES", XR;" RADIANS"
6Ø  PRINT,, "SIN=";SIN XR
7Ø  PRINT,, "COS= ";COS XR
8Ø  PRINT,, "TAN= ";TAN XR
```

(note ,, for line spaces in 6Ø, 7Ø, 8Ø).
Run the program, and try inserting different angles in line 1Ø — check the results in a book of trig tables. Jot down a set of results, for example:

| | | |
|---|---|---|
| 60° | SIN =Ø.866Ø254 | COS=Ø.5 |
| | TAN=1.732Ø5Ø8 | |

Now type the command:

**PRINT ASN** Ø.866Ø254*18Ø/**PI**

and you are back with your original angle of 60°. **ASN** X (ARCSIN on the keyboard) gives you 'the angle in radians whose SIN is X'. ARCCOS and ARCTAN do the same for COS and TAN.

## Here Comes a Chopper

More functions — **INT, ABS** and **SGN** — let's learn by doing:

```
10   LET N=3
1ØØ  PRINT "NUMBER";TAB 8;"INT","ABS";TAB 24;"SGN"
11Ø  PRINT
12Ø  PRINT N;TAB 8;INT N, ABS N;TAB 24;SGN N
```

Put all sorts of numbers into N in line 1Ø — whole numbers, decimal numbers, negative numbers. In case you are feeling lazy, here are some examples:

| *NUMBER* | *INT* | *ABS* | *SGN* |
|---|---|---|---|
| 3 | 3 | 3 | 1 |
| 3.14 | 3 | 3.14 | 1 |
| Ø.14 | Ø | Ø.14 | 1 |
| Ø | Ø | Ø | Ø |
| −3 | −3 | 3 | −1 |
| −3.14 | −4 | 3.14 | −1 |

It's pretty obvious what **INT** is doing (especially if you graduated on a Sinclair ZX80). **INT** chops off and loses the decimal part of a number, leaving the nearest integer (or whole number) which is less than the original number.

3.14 gives 3 (the nearest integer less than 3.14)
−3.14 gives −4 (the nearest integer less than −3.14)

**ABS** is another chopper — this time it removes any negative signs and replaces them with positive signs, in other words **ABS** gives the absolute value of N.

Wield the axe once more with **SGN**. This time the entire number has gone, and we are left with nothing but its sign, + or −, attached to a 1. Ø has no sign, so **SGN** Ø=Ø.

*Exercise 11.1. Decimal part*

There's no function to produce the decimal part of a number — it's up to you. Write a program to print a number and then its integer and decimal parts in three columns.

## Rounding Off Numbers

Computers often produce an embarrassing number of decimal places, so rounding off is a valuable operation. **INT** will not do on its own — to see why, type:

**PRINT INT** 7.Ø1 and **PRINT INT** 7.99

Both give 7, which is obviously unfair to 7.99, which is so very nearly 8. The answer is to add 0.5 to the number before we apply **INT** — this is how it works:

| N | N+Ø.5 | INT (N+Ø.5) |
|---|---|---|
| 7.Ø1 | 7.51 | 7 |
| 7.49 | 7.99 | 7 |
| 7.5 | 8.0 | 8 |
| 7.99 | 8.49 | 8 |

*Exercise 11.2. Rounding to one decimal place*

We've seen how to round numbers to the nearest whole number. Write a program line to round a number to one decimal place. Hint — multiply by 1Ø first, round the result to the nearest whole number, then divide by 1Ø. Try it now.

I hope you managed that one alright. In the same way you can round to any number of decimal places, or to the nearest ten, hundred, and so on.

There's one more important point. ZX81 needs *integers* to follow certain statements. We have met **TAB** n and **LIST** n already, and there are these others:

| | | | | |
|---|---|---|---|---|
| **PLOT** | **UNPLOT** | **RUN** | **DIM** | **GOTO** |
| **GOSUB** | **PAUSE** | **PRINT** | **AT** | **PRINT( TO )** |

You are also allowed to use variables or expressions with these statements — the ZX81 will work out the values for you. The trouble here is that expressions and variables often deliver decimal numbers. Don't worry! ZX81 will also round the values up or down to the nearest integer, just like we did at the beginning of this section.

## We Learnt These in Chapter 11

Functions — maths, trig, **INT, ABS** and **SGN**.
Rounding-off numbers.
Automatic rounding-off by ZX81, when integers are required following statements (**LIST** n and so on).

# 12

# Magic Roundabout

Do you remember *The Sorcerer's Apprentice* in Chapter 3? Here is a mathematical model of a broom filling a 150 gallon water tank at the rate of 4 gallons per trip. We need to make room for a lot of trips, so I am introducing a new statement, **SCROLL**. This moves the contents of the screen one line up, making room for the next item which is printed on the bottom line (like rolling up a scroll!). At this stage the screen is technically full, so to print something else we have to **SCROLL** again. Type in this program:

```
10 LET W=0
20 LET W=W+4
30 SCROLL
40 PRINT W; " GALLONS"
50 GOTO 20
```

Line 10 empties the tank at the start.
Line 20 puts 4 gallons of water in the tank.
Lines 30, 40 print the total water added to the tank so far.
Line 50 contains a really important new statement — **GOTO** 20 means, 'Go straight to line 20 and continue running the program from there'. In other words, 'Take a trip to the well for more water'.

Can you predict the result of this program? Run it and see . . . . . . water, water, everywhere! How can we stop the onward march of the brooms? **BREAK** (bottom right of keyboard, no **SHIFT** needed) is the emergency button, it will always stop the ZX81 while it is working, so press it now. You can restart after **BREAK** by pressing **CONT**, though your screen contents will be lost.

Well, we made a *loop* round lines 20 to 50 — **GOTO** is certainly an easy way to get lots of output! In Chapter 3 we saw that we need to include a *conditional jump* in the loop to check whether the tank is full, we'll do that now. Change line 5Ø and add two more lines:

5Ø **IF** W<15Ø **THEN GOTO** 2Ø
6Ø **SCROLL**
7Ø **PRINT** "TANK FILLED. WHAT NOW?"

There, that worked pretty well, didn't it (apart from a small spill of 2 gallons). Line 5Ø contains the most important bit of programming so far. It is saying, 'Check the value of W, if less than 15Ø then go back to line 2Ø, if it's 15Ø or more go on to the next line'. BASIC wastes no words!

## Relational Operators

Line 5Ø has the general form:

**IF** something is true **THEN** do something
e.g. W<15Ø e.g. **GOTO** 2Ø

The **IF** keyword is always followed by a statement using one of the *relational operators* which are used to *compare* two items:

= equals
< is less than
> is greater than
<= is less than or equal to
>= is greater than or equal to
<> is not equal to

On either side of these operators we put the two items being compared, which may consist of numbers, variables or expressions:

**IF** A=1ØØ **THEN** . . .
**IF** B<Ø **THEN** . . .
**IF** C>A+21 **THEN** . . .
**IF** D<>A+B **THEN** . . .

and so on.

*IF something is true THEN what?*

The program above used:

. . . **THEN GOTO** 2Ø

which is a very common form of conditional statement. However, **THEN** produces the keyword cursor [K] (did you notice?), and it can be followed by any of the keywords, though some don't make much sense. Common ones are:

**GOTO** **PRINT** **LET**
**GOSUB** **RETURN** (we'll meet these later)

Here are some examples of lines with conditional statements:

```
1ØØ  IF X>21 THEN PRINT "OVER 21 AND BUST"
2ØØ  IF T> =Z THEN GOTO 1ØØØ
3ØØ  IF P<Ø THEN LET P=Ø
```

## **GOTO** *where?*

Whether **GOTO** is compulsory or conditional, it must be followed by a line number. In that way you direct the ZX81 to any line in your program, either before or after the **GOTO** line. We can use a line number as such, or we can use a variable or an expression (all variables defined, of course). If the result is a decimal number, the ZX81 will round it off to an integer, and if the line number is non-existent the ZX81 will go to the next line which does exist.

## *How about* **STOP***?*

With all this to-ing and fro-ing, it's as well to know how to stop! Try this program:

```
1ØØ  LET S=78
2ØØ  IF S> =1ØØ THEN GOTO 4ØØ
3ØØ  PRINT "YOU LOST. SCORE= "; S
4ØØ  PRINT "WINNER. SCORE 1ØØ+"
```

If you run it, you'll see that you need something to stop the ZX81 charging on and doing both the orders in lines 3ØØ and 4ØØ .

```
35Ø  STOP
```

Add this and all is well. Try the program with different values of S, and make sure it works.

Now here are two problems for you, each needing loops with **IF** . . . **THEN** statements.

### *Exercise 12.1. Building society interest*

The Society offers you 8% compound interest calculated annually. If you deposit £500 in 1982 and leave it to grow, after one year you have:

$$500 \times \frac{108}{100} = £540$$

After two years:

$$540 \times \frac{108}{100} \text{ and so on.}$$

Write a program to show how your savings build up over seven years, finishing in 1989. Then change one line to round off each result to the nearest penny (see Chapter 11).

*Exercise 12.2. When are the leap years?*

The test for a leap year is 'are the last two digits divisible by 4?' Write a program to print out the years from 1982 to 1999, and say which are leap years. The table below will help:

| Year<br>Y | Year divided by 4<br>Y/4 | *INT* (Y/4) | Is *INT* (Y/4) equal to Y/4? |
|---|---|---|---|
| 1982 | 2Ø.5 | 2Ø | NO |
| 1984 | 21 | 21 | YES |

## We Learnt These in Chapter 12

*Commands*

**BREAK** to stop the ZX81 while it is working.
**CONT** to restart after **BREAK**.

*Statements*

**SCROLL** to move the screen contents up one line so that the next item is printed at the bottom of the screen.
**GOTO** n directs the ZX81 to line n of the program.
**IF** condition **THEN** statement, executes the statement (**GOTO**, etc.) if the condition (X<1Ø, etc.) is met.
**STOP** to stop a program and to avoid crashing into later program lines.

*Anything Else*

Relational operators (=, <, >, <=, >=, <>) to compare two items.

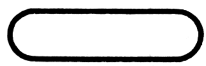
# 13

# Flowcharts

We are able to write quite complicated programs, now that we have learnt about loops and conditional branching. At this stage, it is worth reminding ourselves about *flowcharts* as an aid to good programming.

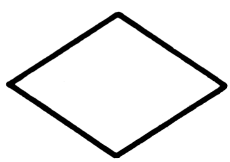
Suppose you have some operation for which you want to write a program — let's use the sorcerer's apprentice idea from Chapter 3 as an example. The idea of a flowchart is to split the operation up into separate stages, to write each stage in a box, and to join the boxes by arrows to show the order in which the stages have to be done. We use boxes of these shapes:

Beginning or end.



'Processing block' — one stage of the operation which needs no decision.

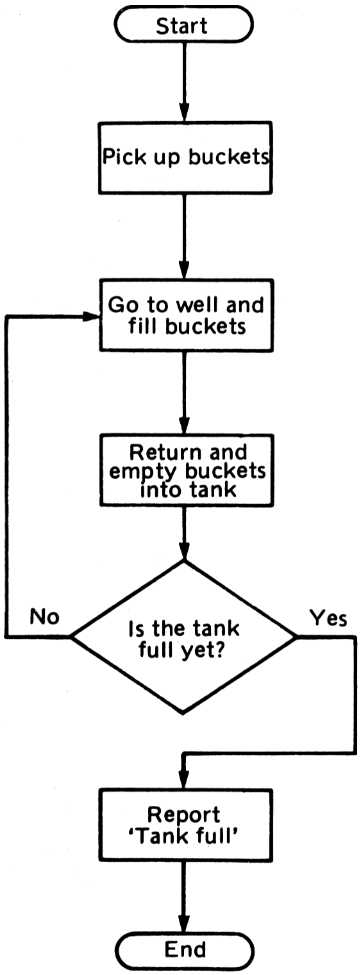
'Decision diamond' — here a question is asked and the flowchart branches to either side depending on the answer.



Now we can draw up a flowchart for filling the water tank from the well. Compare it with the original program in Chapter 3, and with the mathematical model in the last chapter. Notice how the place of the IF . . . THEN . . . statement is taken by the decision diamond.

Some people can carry a flowchart in their heads and type out a program direct. However, most of us will benefit from drawing up a flowchart on paper first. We'll see more examples of flowcharts for ZX81 programs later.

*Broom filling water tank from well*



# 14

# Putting in Data

Let's go back to Exercise 12.1 in Chapter 12 — you'll find the listing in Appendix 4. Not a bad program, giving you interest at 8% a year for 7 years on your £500, but what a bore if you want to change your capital — you have to retype line 4∅. Well, we can do better than that. Type out the listing for Exercise 12.1, but change line 2∅ to read:

2∅ **INPUT** C

Run the program — what's this? A blank screen with an [L] cursor at the bottom! ZX81 is trying to say, 'I've stopped and I'm waiting for you to put in a value for variable C'. Type 5∅∅ and then press **NEWLINE** — you'll get just the same output as you got before with:

2∅ **LET** C=5∅∅

but of course now you can make C different every time you run. Try running a few times and varying C. **INPUT** is great!

It makes things easier for people using your programs if you print a 'prompt' to tell them what data they are supposed to be putting in. Add one more line:

1∅ **PRINT** "WHAT IS YOUR CAPITAL?"

Much easier to use now, isn't it? Stay with us, there's more to come.

## Input Loops

After running the program, suppose you want it to go back to the beginning and run again with different capital. What instruction would you use? You guessed it:

15∅ **GOTO** 1∅

Type that in, and run it twice with different values for C.

Hmm . . . not so good, it crashed with a 5/1ØØ report code. You can check that in your manual — it means 'screen full', and we've got to do something about that next. We could use **SCROLL**, can you imagine your output rolling up the screen with a pause now and again for input. In this case it's more elegant to wipe the screen before each new printout — the statement is **CLS** (clear screen). Here's the complete listing:

```
 1Ø  PRINT,, "WHAT IS YOUR CAPITAL?"
 2Ø  INPUT C
 3Ø  CLS
 5Ø  LET Y=1982
1ØØ  PRINT Y;" CAPITAL+INTEREST=£";C
11Ø  PRINT
12Ø  LET Y=Y+1
13Ø  LET C=C*1.Ø8
14Ø  IF Y<199Ø THEN GOTO 1ØØ
15Ø  GOTO 1Ø
```

We now have two loops, one inside the other (nested). Why can't we put **CLS** at the beginning of the outside loop? Try it.

## Getting Out of an Input Loop

Well — it's not the most enthralling of programs, but how do you stop it, it seems capable of demanding data for ever! The official way is to type **STOP** at the next pause for input, and then **NEWLINE** will stop the program with a D/2Ø message. If you happen to want to restart you type **CONT**, the ZX81 will still be at line 2Ø waiting for data, though **CONT** will have cleared the screen.

## Permanent Loops

This input loop is a permanent loop, which is really only allowable because of the **INPUT** statement which stops it in line 2Ø. If we change line 2Ø back to:

```
2Ø  LET C=500
```

we shall find that the poor old ZX81 chunters round and round the outside loop indefinitely — or until we press **BREAK**. Some bad programming there!

Now for some examples for you to try, using **INPUT** loops:

*Exercise 14.1. Percentages*

Write a program to convert your exam results into percentages. You'll have to input your mark, the maximum possible mark, and then use

$$\frac{\text{Mark}}{\text{Max. mark}} \times 100 = \text{Mark\%}.$$

*Exercise 14.2. Petrol consumption*

Write a program to input the number of miles driven, gallons used, and to calculate miles per gallon.

## We Learnt These in Chapter 14

*Statements*

**INPUT** to stop the program to enter values of variables.
**CLS** to clear the screen to make room for more output.
**STOP** as input to get out of an input loop.
**CONT** to restart after **STOP**.

*Anything else*

Input loops to stop repeatedly to collect data.

# 15

# Saving Programs and Data

## Using the ZX Printer

Imagine, you've written a program that works and you want to make a permanent record of it. When you switch off, the program will be lost and you'll have to work it out again. Obviously you can write it down on paper, but this is hard work and it's easy to make mistakes. It's very much easier if you happen to own a Sinclair ZX Printer, and you have had the forethought to plug it in before you started (Sinclair recommend that you do not connect the printer without switching off first). In this case you can make a list on paper of all the lines of your program by typing the command **LLIST**. If you only want to record part of the program, you can type **LLIST** n to list from line number n onwards, and you can always press **BREAK** to stop printing whenever you like.

Another way of using your printer is to make a record on paper of any data that your program has worked out and printed on the TV screen. Use the keyword **COPY**, either as a command or a statement, to make the printer record the whole contents of the TV screen on paper.

## Back-up Storage

Whether you have copied the program by hand or with the ZX printer, you have a lot of typing to do when you want to use it again. You can save yourself all that typing by putting the program into *back-up storage*, which for the ZX81 means almost any tape recorder.


*The ZX81 and the ZX Printer, designed especially for use with Sinclair personal computers*

## Saving a Program

My cassette recorder has 3.5 mm jack plugs for microphone (MIC) and earpiece (EAR) and automatic recording level. It has a reliable tape counter (very useful), and a red LED indicator for recording level (a meter is just as good). If your own tape recorder lacks some of these features, you may have to adapt, and you will probably find it less convenient.

You'll need to keep a tape specially for ZX81 programs, with a careful record of its contents. Here is a list of operations that work for me — if you run into trouble you will find Chapter 16 in the ZX81 Manual very helpful.

(1) Connect the MIC sockets on ZX81 and recorder.
(2) Wind the tape back to the start, zero the counter, wind the tape on to an empty stretch and note the counter reading.
(3) If you wish, record the name of the program on tape using your microphone (useful if you have no counter).
(4) Type the command **SAVE** "NAME" (your choice of name). Make a note of the name.
(5) Press the RECORD and PLAY keys on the tape recorder, then press **NEWLINE**. After a five-second blank, you will see a

quickly changing set of thin black and white stripes (your program). Check that it is being recorded (LED or meter).

(6) At the end, the screen will go blank with a Ø/Ø report code. Switch off the tape recorder. Your program is still unchanged in the ZX81.

It's best to leave decent spaces — say five seconds — between the programs on your tape. A full 1 K program takes about 15 to 20 seconds to record.

## Loading Your Program

Tomorrow has come — you want to put your program back into the ZX81. This is how I do it.

(1) Wind the tape to the point where recording started.
(2) Connect the EAR sockets on ZX81 and recorder.
(3) Type **LOAD** "NAME" or **LOAD** " ".
(4) Set the tape recorder volume to about 3/4 of maximum, and any tone controls to maximum treble, minimum bass.
(5) Press **NEWLINE** — you will see various fairly even patterns on the screen, and then suddenly a rapidly moving pattern of horizontal bars, a bit like a venetian blind gone crazy. This is your program.
(6) After loading, the screen will clear with a Ø/Ø report code. Switch off the tape recorder.
(7) You can now press **NEWLINE** for a listing of the program, or **RUN** to run it.

## It's Better to Load a Named Program

One gets lazy and stops bothering to type the program name in the quotes after **LOAD**, but this makes loading less reliable. If you have named the program, the ZX81 will ignore all others, even the tail of a previous program. In fact if required the ZX81 will search through a tape and load the named program. You must get the name *exactly* right — one letter or space wrong and nothing will be loaded.

## Saving Data

Many computers use DATA and READ statements which allow program lines containing many items of data. ZX81 does not have this facility, and it is obviously tedious to put this data in by means of

**LET** statements, or to input the data each time the program is run.

All is not lost, however! It's very important to realise that once you have run a program and put in data with **INPUT**, there are only three operations which will get rid of that data:

(1) Switching off the ZX81.
(2) Pressing **RUN** again.
(3) Pressing **CLEAR** (a little used key which erases all variables).

To make the program work without pressing **RUN** we have to use **GOTO** as a command. Type this short program:

```
 1Ø INPUT A
 2Ø INPUT B
 3Ø INPUT C
1ØØ PRINT A; B; C;" GO"
```

Now type the command **GOTO** 1ØØ — you'll get the 2/1ØØ report code meaning 'variable not known'. **RUN** the program and put in values of 1, 2, 3 for variables A, B, C — this time you'll get the expected output:

123 GO

*Now* if you command **GOTO** 1ØØ, you'll get exactly the same output — the data is still all there! Without doing anything else, **SAVE** the program in the usual way, and with it you have saved your data. If you want to check up on this, first unplug the ZX81 for a moment to remove the possibility of cheating! Then **LOAD** in the usual way, command **GOTO** 1ØØ, and the output:

123 GO

will confirm that the data is still there. If you type **RUN** at any stage, the data vanishes, and you will have to put it in again. One last point. When you are really pushed for memory space, you may find that this will save some useful bytes:

(1) Write the part of the program needed for putting in the data.
(2) Run the program and input the data.
(3) Delete the program written in (1) and write the part of the program that uses the data.
(4) Save program plus data, and use **GOTO** n to make the program work — never **RUN**!

## We Learnt These in Chapter 15

*Commands*

**LLIST** or **LLIST** n to list a program on paper using the ZX Printer.

**COPY** to make a copy of the contents of the TV screen on paper, using the ZX Printer. This can also be used as a statement in a program.
**SAVE** to transfer programs from the ZX81 onto tape.
**LOAD** to put taped programs back into the ZX81.
**GOTO** n to execute a program from line n without clearing any data.

*Anything else*

How to save data on tape and use it again.

# 16

# Round and Round — Just Ten Times

With a quick look back to Chapter 12, you could write a program to go round a loop exactly ten times, couldn't you?

```
1Ø  LET J=Ø
2Ø  LET J=J+1
3Ø  PRINT J;" TIMES ROUND THE LOOP"
4Ø  IF J<1Ø THEN GOTO 2Ø
5Ø  PRINT
6Ø  PRINT "STOPPED FOR A REST"
```

BASIC has special statements to do the same job — change the above program as follows:

```
Delete line 1Ø
2Ø  FOR J=1 TO 1Ø
4Ø  NEXT J
```

Run it — the output is identical — **FOR/NEXT** is a wonderful time saver. To see how it works, study the complete program and the flowchart opposite.

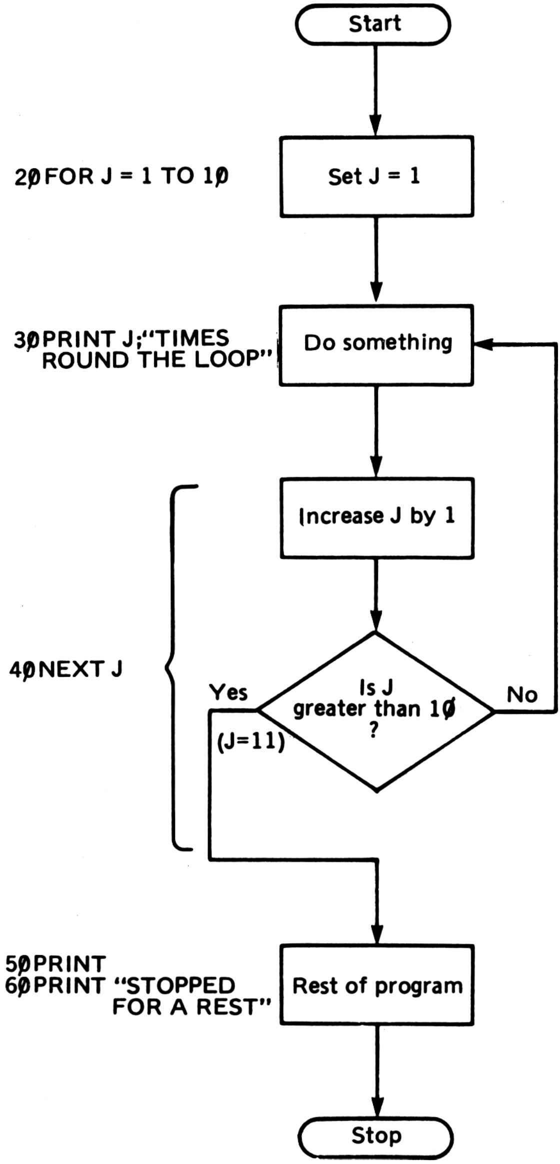
Here are some points about **FOR/NEXT** loops:

(1) N is the *loop control variable.* It may have any single letter name from A to Z, but steer clear of letters you are using elsewhere for ordinary variables.

(2) The numbers on either side of **TO** are the lower and upper limits for the loop control variable. As usual they may be numbers, variables or expressions, but the ZX81 does not round off values in this case.

(3) The loop control variable is increased by 1 each time round the loop. Note that it finishes up 1 more than the upper limit for the loop.

(4) Inside the loop may be any number of program lines with




any of the usual statements. You can do anything you like which *uses* the value of N, so long as you don't change it. Remember that N increases by 1 each time round the loop.

(5) You may jump out of the loop with an **IF/THEN GOTO** statement, but don't jump into the middle of a **FOR/NEXT**

loop — the ZX81 will not know what the loop control variable is.

(6) **FOR** without **NEXT** is incorrect but will be ignored. **NEXT** without **FOR** will stop the program with a 1/n or 2/n error.

Now try out your **FOR/NEXT** technique with this problem:

*Exercise 16.1. Square root table*

Write a program to print out the whole numbers from Ø to 16 with their square roots alongside, under a suitable heading.

## Step by Step

Hold on tight for the next revelation — we don't *have* to increase by 1 each time round a **FOR/NEXT** loop! If we add the magic word **STEP**, we can increase by any regular amount we like, or decrease by using a negative step. Some examples:

**FOR** N=1 **TO** 12 **STEP** 3
**FOR** J=8 **TO** Ø **STEP** −1
**FOR** K=P **TO** Q **STEP** 3*R
**FOR** L=Ø **TO** 5 **STEP** Ø.5

Try changing the appropriate line in your last square root program:

**FOR** N=Ø **TO** 16 **STEP** 2

and

**FOR** N=16 **TO** Ø **STEP** −2

Now try this exercise using **FOR/NEXT/STEP**:

*Exercise 16.2. Multiples*

Write a program to print out all the multiples of 4 between Ø and 1ØØ, in four neat columns. Hint — use the current value of the loop control variable not only as the multiple of 4, but also to direct where it is printed on the line.

## We Learnt These in Chapter 16

*Statements*

**FOR/TO/NEXT** to go round a loop any given number of times.
**STEP** to specify increases or decreases in the loop control variable, other than +1.

# 17

# Loops Within Loops

In the last chapter, every program had one single **FOR/NEXT** loop. But the number of loops in a program is not limited — try this for a start:

```
10  FOR J=0 TO 4
20  PRINT TAB J; "FIRST LOOP"
30  NEXT J
40  PRINT
100 FOR J=10 TO 12
110 PRINT TAB J; "SECOND LOOP"
120 NEXT J
```

Notice that we used J for both loop control variables — quite in order for separate loops, and a useful memory saver.

Here is a different program — note the difference in output.

```
10  FOR J=1 TO 3
20  PRINT "OUTSIDE LOOP"
30  FOR K=1 TO 5
40  PRINT TAB 5; "INSIDE LOOP"
50  NEXT K
60  NEXT J
```

This time we have a 'K loop' *inside* the 'J loop' — we call these *nested loops.* You can use up to 26 nested loops, but they must obey two important rules:

(1) You must use different letters for the loop control variables.
(2) Inner loops must be completely inside outer loops — no overlapping at either end.

Remember those addition squares in school maths? Here's a small example:

```
0   1   2
1   2   3
2   3   4
```

If you trace down from the 1 in the top row and along from the 2 in the left hand column, your lines meet at 3, showing that 1+2=3. We can draw these squares neatly with the ZX81:

```
10  FOR J=0 TO 5
20  FOR K=0 TO 5
30  PRINT TAB 4*K; J+K;
40  NEXT K
50  PRINT,,,,
60  NEXT J
```

Now an exercise for you to play with.

*Exercise 17.1. Multiplication square*

Here is a small multiplication square which works in the same kind of way:

```
1   2   3
2   4   6
3   6   9
```

Change the last program for the addition square, to draw out a multiplication square covering numbers from 1 up to 7.

## Simple Graphics

Graphics and loops often go together, so let's have a look at the graphic blocks on the keyboard. Remember that you must press the **GRAPHICS** key first, and then again when you have finished. Each graphic block is a square the size of a letter, divided into four smaller squares which can be black, white or (to a limited extent) grey. They are beautifully illustrated on page 78 of your ZX81 manual. There are also inverse letters and some inverse symbols, and inverse space (black square) gets a lot of use. We can make the ZX81 print any of the graphic blocks as though they were letters — here's an 8 by 8 grey square as an example:

```
100  PRINT "▒";
```

Type it and run it — one square drawn, 63 to go! Add these lines:

```
 90  FOR K=1 TO 8
110  NEXT K
```

Brilliant! A row of 8 blocks this time. Add two more lines, to give us 8 of these rows:

```
 8Ø  FOR J=1 TO 8
13Ø  NEXT J
```

We have 64 blocks now, but they're not exactly in the form of a square. What went wrong? That's right, it's the semi-colon after each block that is printing them all in a continuous line. We need to jump to a new line after each set of 8 blocks — in other words at the end of each J loop. One more line will do it:

```
12Ø  PRINT
```

and now your square is looking good, thanks to nested loops.
It's your turn now:

*Exercise 17.2. Rectangle*

Write a program to draw a black rectangle 19 blocks wide and 5 blocks high.

Now modify your program so that it prints a title "THIS IS A RECTANGLE" in inverse graphics right in the middle of the rectangle.

There's plenty more to do with graphics — to be continued in Chapter 23.

## We Learnt These in Chapter 17

Multiple loops and nested loops.
Simple graphics, using the graphics blocks.

# 18

# What a Friendly Machine!

Remember **LET** and **INPUT**? They were two ways of putting a *value* into a *numeric variable*. Wouldn't it be great to be able to do the same for words? Now for the good news, you can do all that and more! Here is a sample:

```
10 PRINT "TYPE YOUR NAME THEN NEWLINE"
20 INPUT A$
30 PRINT "THANK YOU "; A$
40 FOR J=1 TO 200
50 NEXT J
60 PRINT ,, "THATS A PRETTY NAME"
```

A$ is the big news — it's the name of a *string variable*. At line 20 the program stops, and the cursor [L] at the bottom of the screen tells us that the ZX81 is waiting for a string input. So we type in any characters we like (or even none at all, the empty string), press **NEWLINE**, and our string is pigeonholed under the label A$. We can now use A$ any time we wish, as in line 30. Lines 40 and 50 are an empty **FOR/NEXT** loop, a handy way of pausing in between outputs. You can use up to 26 string variables with names using any single letter from A to Z, followed by the $ sign.

If we add two more lines:

```
70 GOTO 10
25 CLS
```

we now have a *string input loop*, and we can continue typing names (pretty ones) as long as we like. These loops are somewhat hard to get out of, since whatever we type in is accepted by the ZX81 as a new string input. Try typing **STOP** for example. The solution is to remove the string input quotes at the bottom of the screen — pressing **EDIT** is the simplest way, or you can rub them out as usual.

Now if you press **STOP** and then **NEWLINE** you will find that you are back in the command mode.

Now here is a program in which we use **LET** to define two string variables.

```
10  LET A$="REGENT"
20  LET B$=" STREET"
30  LET C$=A$+B$
40  LET N=10
50  PRINT "WHO LIVES AT   "; N; C$; "?"
```

In line 30 we have joined together two string variables (*concatenated* is the official word), and put the result into a third string variable. In line 50 we have printed a whole mixture of items, literal strings, number and string variables, all on one line of the screen. We can print any of these items anywhere we like on the line by using ; , or **TAB** as usual.

## What Can You Do with String Variables?

As we've seen, you can print them, as often as you like, and you can join them together like a string of beads by using + (– will not work, by the way). You can also change them in a program, just like number variables. For example:

```
25  LET A$=" DOWNING"
```

We've changed our mind about A$!

One more thing you can do is to *compare* string variables, either with each other or with literal strings, using our old friend **IF**. More lines for you to type:

```
 60  INPUT P$
 70  PRINT ,, P$
 80  IF P$="THE PRIME MINISTER" THEN GOTO 100
 90  GOTO 50
100  PRINT ,, "THATS RIGHT"
```

In line 80 we have used = to compare the input answer P$ with the literal string "THE PRIME MINISTER". Note that in BASIC, = means exactly equal — every letter, dot, comma and space must be identical! Run the program and vary the input to check this. Try writing the program in a simpler way:

```
80  IF P$ <> "THE PRIME MINISTER" THEN GOTO 50
Delete line 90
```

Occasionally we use > and < to compare string variables. This program will show you exactly what happens:

```
 1Ø  PRINT "TYPE A WORD"
 2Ø  INPUT A$
 3Ø  PRINT "NOW ANOTHER"
 4Ø  INPUT B$
 5Ø  PRINT,,A$; " COMES ";
 6Ø  IF A$>B$ THEN GOTO 1ØØ
 7Ø  PRINT "BEFORE ";
 8Ø  GOTO 11Ø
1ØØ  PRINT "AFTER ";
11Ø  PRINT B$, " IN THE DICTIONARY"
```

Run the program and input ARK and ZOO, then ABRACADABRA and AARDVARK. Now you know what > means when applied to strings.

This chapter has taken our programming a long way forward. Here is a simple program to practise your string variables.

*Exercise 18.1. Form filling*

Write a program requesting someone to type their name, age and home town. Print out the information and thank the person nicely.

## Using the Printer Again

Now that we know how to print numbers, literal strings, number and string variables on the screen, under the control of punctuation and **TAB**, it is important to note that we can print all these on paper just as easily. We need the ZX Printer, which must have been plugged in before we switched on, and we use **LPRINT** in place of **PRINT** all through the program. You can even mix up **PRINT** and **LPRINT** statements. This program puts odd numbers on the TV screen and even numbers on paper:

```
 1Ø  FOR J=1 TO 2Ø
 2Ø  IF J/2=INT (J/2) THEN GOTO 1ØØ
 3Ø  PRINT J
 4Ø  GOTO 2ØØ
1ØØ  LPRINT J
2ØØ  NEXT J
```

Now after running the program, change one line as follows:

```
1ØØ  LPRINT J;" ";
```

This time we are making the ZX81 print the even numbers all on one line. Notice how the printer saves them up till the end of the program, and then prints them all at once. The ZX Printer stores up its **LPRINT** items in a *buffer* store until there is some reason to print the current buffer contents and move on to the next line, for example:

end of program
current line full
last **LPRINT** item not followed by ; or ,
**TAB** number less than the current print position.

## We Learnt These in Chapter 18

*Statements*

**LET** to define a string variable.
**INPUT** to stop the program to input a string variable.
**LPRINT** to print any item on paper, using the ZX Printer.

*Anything else*

Printing and joining string variables.
Comparing string variables and strings using **IF** with
=, <>, > or <.

# 19

# Change Speed, Stop and Pause

All the programs in this book so far will have worked for both ZX81 and ZX80 (with 8K ROM). However, while ZX81 owners have been watching the work in progress on their screens while the programs are running, ZX80 fans have had to sit in front of blank grey screens, waiting for a final print out.

With a ZX81 you can choose to run it like a ZX80 by typing the command **FAST**, and it then works at four times the speed of the usual **SLOW** mode. Indeed, you can get the best of both worlds by using **FAST** and **SLOW** as statements in your programs. In the following program you can compare **FAST** and **SLOW** working:

```
 1Ø  FAST
1ØØ  CLS
11Ø  FOR J=1 TO 4Ø
12Ø  LET C=EXP (LN J/3)
13Ø  PRINT C,
14Ø  NEXT J
2ØØ  STOP
21Ø  SLOW
22Ø  GOTO 1ØØ
```

The program first works out a set of 40 cube roots in **FAST** mode, and when they are all done it displays them (thanks to **STOP**). Now if you type **CONT**, it will change to **SLOW** mode and do the same work again.

The choice of **FAST** or **SLOW** is a matter of personal preference, but here is a rough guide:

**FAST** preferred:
  complicated calculations
  tedious printouts

program writing, provided you don't mind the screen flashing each time you press a key.

**SLOW** preferred:

most programs, especially those using graphics.

**SLOW** essential (in other words, ZX80 will not do)

programs with moving graphics, bouncing balls, flashing words, and so on.

By the way, when you save a program you also save the mode the ZX81 happens to be in, whether **FAST** or **SLOW**. Make sure it's in the mode you want.

## Stopping Your Program

These things will make your program come to a stop:

(1) It has reached the end and stopped with a Ø/n report code.
(2) You have pressed **BREAK** and stopped it with a D/n code.
(3) A **STOP** statement was included in one of your program lines (9/n code).
(4) You have used up all the lines in the screen and stopped with a 5/n code.
(5) Some other error has stopped the program (various codes).
(6) It has reached an **INPUT** statement and is waiting for you to enter a number or a string.

The last is the most useful of all. You can use it to stop the program, look at the display on the screen, and re-start when you are ready. Look at this program, which shows you how fast bacteria grow under favourable conditions. Doubling every 30 minutes is fairly typical, ignoring the fact that they also run out of food or die.

```
 1Ø  LET N=1
 2Ø  LET T=Ø
 3Ø  CLS
 4Ø  PRINT T; " HOURS HAVE GONE BY"
 5Ø  PRINT,, "YOUR CULTURE CONTAINS "; N; " BACTERIA"
 6Ø  LET T=T+Ø.5
 7Ø  LET N=2*N
 8Ø  PRINT,,,, "PRESS NEWLINE TO GO ON"
 9Ø  INPUT A$
1ØØ  GOTO 3Ø
```

Notice how we could input anything at line 9Ø, but the empty string (just pressing **NEWLINE**) is all that's needed to start the program moving again.

## Program Branching and Crashproofing

We can use a similar technique to allow a user the choice of branching to different parts of the program:

```
1ØØ  PRINT "TYPE YES OR NO"
11Ø  INPUT A$
12Ø  IF A$="YES" THEN GOTO 2ØØ
14Ø  PRINT "YOU TYPED NO"
15Ø  STOP
2ØØ  PRINT "YOU TYPED YES"
```

Run the program and obey the instructions, typing YES or NO obediently. Now be a devil and type DONALD DUCK — the program stoutly declares 'YOU TYPED NO'!

A warning — the world is full of clever dicks who are out to try and make computers look silly. You must also think of the newcomers to computing — they'll be put off for ever if they keep getting report codes and having to start again. All programmers are responsible for making their programs foolproof and vandalproof as far as possible. Hard to do with 1K of memory, but at least remember the principle for later!

Let's patch up the last program by adding:

```
13Ø  IF A$<> "NO" THEN GOTO 11Ø
```

Much better now — I've drawn two flowcharts to make it clear what is happening in each version. Over to you now:

*Exercise 19.1. Choosing numbers*

Write a foolproof program to ask the user to input a whole number between 1 and 100, and to print out the number together with its square. Include lines to make sure that it *is* a whole number and between 1 and 100. There is one input error you can *not* guard against at present — what is it?

## Pauses in Programs

ZX81 has a built-in pause statement — let's see how it works:

```
1Ø  PRINT "HOW LONG?"
2Ø  PRINT " TYPE NUMBER OF SECONDS"
3Ø  INPUT S
4Ø  PRINT S; " SECOND PAUSE STARTS NOW"
5Ø  PAUSE S*5Ø
6Ø  PRINT "TIMES UP"
```

The statement **PAUSE** n gives a pause equal to n frames on the TV screen (at 50 per second in the UK). It works in **SLOW** or **FAST** mode, but in **FAST**, or with a ZX80, the manual recommends that you follow each **PAUSE** statement with this line to avoid losing your program.

Line Number **POKE** 16437,255

I have not had this problem with **PAUSE** in **FAST** mode, but you have been warned! You can't pause for more than 32767 TV frames (nearly 11 minutes), and if n is bigger than this the pause is for ever. However, if you press any key during a pause the program restarts at once, so this is another way of stopping a program to read the current display:

```
200 PRINT "PRESS ANY KEY TO GO ON"
210 PAUSE 40000
220 PRINT "BACK TO WORK"
230 GOTO 220
```

## We Learnt These in Chapter 19

*Commands*

**FAST** to put the ZX81 into **FAST** mode.
**SLOW** to return the ZX81 to **SLOW** mode.

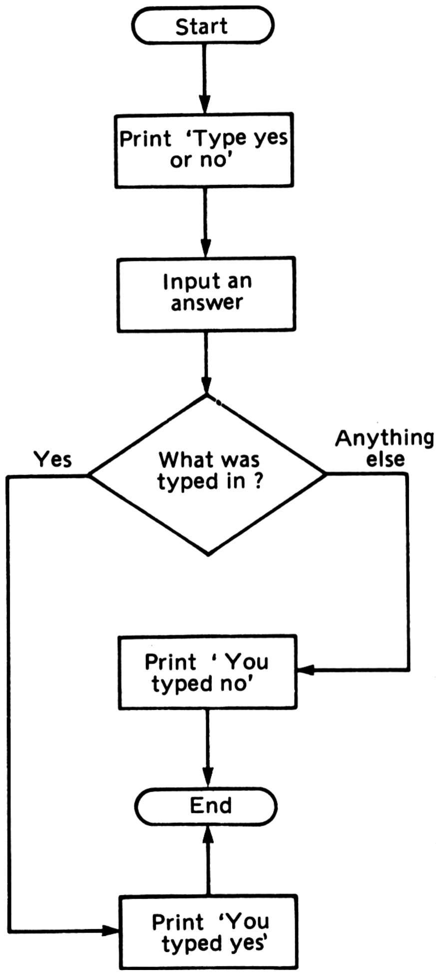
*Statements*

**FAST** and **SLOW** as above.
**PAUSE** n to give a pause in the program.

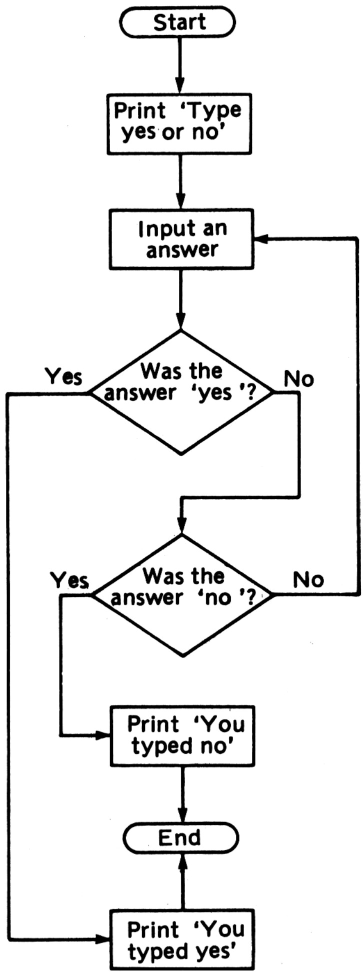
*Anything Else*

When to use **FAST** and **SLOW** modes.
**INPUT** or **PAUSE** for temporary stops in the program.
Making the program branch, under control of a string input by the user.
Crashproof programs.

The YES/NO program  1. Subject to the attention of vandals



The YES/NO program 2. Vandal-proof version



# 20

# A Chancy Business

## Random Numbers

There's a simple random number generator we've all used — the dice. This obeys certain obvious rules. It can only give numbers from 1 to 6. Unless it is loaded, or an odd shape, each of the numbers is equally likely to turn up. Finally, being a dumb piece of wood or plastic, it is not affected by anything that has happened before. We can turn these into general rules for random numbers:

(1) A random number is one drawn from a given set of numbers.
(2) Each number in the set is equally likely to be drawn.
(3) The draw is completely unaffected by previous draws.

ZX81 provides a random number function, **RND** — let's try it out:

```
100 FOR J=1 TO 20
110 PRINT RND
120 NEXT J
```

Run it a few times — what do you notice? Sets of twenty numbers, each one bigger than 0 and less than 1, and they certainly look fairly random. In fact they are *pseudo-random numbers* — each one is calculated in a clever way from the one before, so that rules (1) and (2) are obeyed. However, they always start with the same 'seed' number when the ZX81 is switched on, and the same sequence of numbers will always be repeated (you can check this if you want to). Playing games with the same set of dice throws every time is a bit predictable, to say the least. Fortunately ZX81 provides a statement which sets a random 'seed' number at the start:

```
10 RAND
```

Now you'll get a different set of random numbers each time you switch on and run (you can check this too!).

If we do want the ZX81 to throw dice, how are we going to convert our **RND** values into numbers from 1 to 6? Have a look at this:

| *Set of Numbers given by* | *Smallest* | *Largest* |
|---|---|---|
| **RND** | 0.000 . . . | 0.999 . . . |
| **RND***6 | 0.000 . . . | 5.999 . . . |
| **RND***6+1 | 1.000 . . . | 6.999 . . . |
| **INT** (**RND***6+1) | 1 | 6 |

So, change line 11Ø in our program:

```
11Ø  PRINT INT (RND*6+1)
```

Now we really do seem to be throwing dice. By taking **RND**, multiplying it by one number and adding or subtracting another number, we can change it to any range of numbers we like.

*Exercise 20.1. Roulette*

Write a program to fill the screen with spins of a roulette wheel, which in the best games vary from 0 to 36. Check that 0 and 36 really do appear.

At the end of Chapter 11 we looked at various statements which needed numbers to go with them. You can often use random numbers, as with this constellation program:

```
1Ø  FOR J=Ø TO 21
2Ø  PRINT TAB RND*31; "*"
3Ø  NEXT J
4Ø  PAUSE 5Ø
5Ø  CLS
6Ø  GOTO 1Ø
```

Remember that we need not do anything to **RND***31 in line 2Ø, it's automatically rounded to the nearest whole number between Ø and 31.

In the same way we can use random numbers to define the size of a **FOR/NEXT** loop, though here no rounding off takes place and it may be advisable to convert the random numbers to integers. You try this one:

*Exercise 20.2. Random rectangle*

Write a program using nested **FOR/NEXT** loops to draw a rectangle of random size (length and breadth varying between 1 and 15).

## Random Branching

We have learnt how to stop a program and give the user a *choice* of two or more branches to go along. Using **RND**, we can remove the choice and let the branching happen by chance. Here's a simple example:

```
 1Ø  PRINT "YOU ARE WALKING HOME",,,
 2Ø  IF RND<.5 THEN GOTO 1ØØ
 3Ø  FOR J=1 TO 15
 4Ø  PRINT TAB J; " "
                          (GRAPHICS/SHIFT YYAHYY)
 5Ø  NEXT J
 6Ø  PRINT,, "YOU WENT THE PRETTY WAY"
 7Ø  GOTO 2ØØ
1ØØ  PRINT,, "SHORT CUT"
2ØØ  PRINT,, "YOU ARE HOME"
```

Another way of branching at random is to **GOTO** a random number. Here is a program which draws blocks out of a bag containing equal numbers of black, grey and checked blocks.

```
 5Ø  FOR J=Ø TO 5
 6Ø  LET X=1ØØ * INT (RND*3+1)
 7Ø  GOTO X
1ØØ  FOR K=1 TO 3
11Ø  PRINT TAB 5*J;" " (3 of GRAPHICS/SPACE)
12Ø  NEXT K
13Ø  NEXT J
14Ø  STOP
2ØØ  FOR K=1 TO 3
21Ø  PRINT TAB 5*J; " " (3 of GRAPHICS/SHIFT H)
22Ø  NEXT K
23Ø  NEXT J
24Ø  STOP
3ØØ  FOR K=1 TO 3
31Ø  PRINT TAB 5*J; " " (3 of GRAPHICS/SHIFT Y)
32Ø  NEXT K
33Ø  NEXT J
```

Notice that the last part of the program is repeated three times at lines 1ØØ, 2ØØ and 3ØØ — bad programming and a waste of memory. We'll improve on this in the next chapter.

## We Learnt These in Chapter 20

*Statement*

**RAND** to pick a random seed for calculation of random numbers.

*Function*

**RND**, a pseudo-random number between 0 and 1.

*Anything else*

Using random numbers.
Random branching in a program.

# 21

# Gone Out, Bizzy, Back Soon

## Subroutines

The statement **GOSUB** n is related to **GOTO** n and is extremely useful. It tells the ZX81,

(1) To go to the part of the program at line n.
(2) To do what it is told to there.
(3) To come back to the part of the program that it started from.

Here is a very simple demonstration:

```
100  PRINT "SUBROUTINE DEMO"
110  PRINT,, "JUST OFF TO SUBR 1000"
120  GOSUB 1000
130  PRINT "RETURNED"
140  PRINT,, "ON THE WAY TO SUBR 2000"
150  GOSUB 2000
160  PRINT "BACK AGAIN"
```

Run it now and see what happens. Well, it obeyed lines 100 to 120, went off to line 1000, found nothing there and stopped. We must write in the subroutines:

```
1000  PRINT TAB 5; "THIS IS SUBR 1000"
2000  PRINT TAB 5; "WE ARE AT SUBR 2000"
```

Not right yet — it went to line 1000 as planned, didn't go back again but went on to line 2000 and stopped. We need to put in the instructions to make it return from each subroutine — **RETURN**. We'll also put in a **STOP** to fence off the subroutines from the main program:

```
 900  STOP
1000  PRINT TAB 5; "THIS IS SUBR 1000"
```

```
1Ø1Ø  RETURN
2ØØØ  PRINT TAB 5; "WE ARE AT SUBR 2ØØØ"
2Ø1Ø  RETURN
```

Run the program and make sure it works. It's worth writing down the program lines in the order that they are used:

1ØØ, 11Ø, 12Ø, 1ØØØ, 1Ø1Ø, 13Ø, 14Ø, 15Ø, 2ØØØ, 2Ø1Ø, 16Ø, 9ØØ

Now that we've learnt something about subroutines, we can write down some formal rules:

(1) At **GOSUB** n the ZX81 goes straight to line n (or to the next line if n does not exist). n may be a number, a variable or an expression.
(2) The ZX81 executes the subroutine just as though it is part of the main program.
(3) The subroutine must finish with a **RETURN** statement, which sends the ZX81 back to the line following the original **GOSUB** n statement.
(4) You may jump out of one subroutine into another, provided you are very clear-headed about what you are doing!
(5) It is often useful to have a conditional **GOSUB** in your program:
    **IF** something is true **THEN GOSUB** n.
(6) Put all your subroutines at the end of your program, and use **STOP** between main program and subroutines to avoid crashing into them.

We can often usefully include **GOSUB** in a loop — here is a new version of the random cube drawing program in the last chapter. It's much shortened by the use of **GOSUB**:

```
 1Ø  FOR J=Ø TO 5
 2Ø  LET X=1ØØ *INT (RND*3+1)
 3Ø  FOR K=1 TO 3
 4Ø  GOSUB X
 5Ø  NEXT K
 6Ø  NEXT J
 9Ø  STOP
1ØØ  PRINT TAB 5*J; "███" (3 of GRAPHICS/SPACE)
11Ø  RETURN
2ØØ  PRINT TAB 5*J; "▒▒▒" (3 of GRAPHICS/SHIFT H)
21Ø  RETURN
3ØØ  PRINT TAB 5*J; "▚▚▚" (3 of GRAPHICS/SHIFT Y)
31Ø  RETURN
```

## When Should We Use Subroutines?

As we have already seen, it makes sense to use a subroutine when we want to leave the main program at several points and do the same operation each time. Subroutines save both computer memory and programmers' time and effort.

Another reason for using subroutines is to make a long program easier to understand. We divide it up into:

A main program, which may be quite short.
A set of subroutines, labelled with **REM** statements.

It is also a great help to keep lists of your subroutine numbers and titles, and of all the variable names used.

Finally, you will write clever bits of program which you will want to use again. How much easier this will be if they are in the form of subroutines which can be transferred bodily to a new program.

*Exercise 21.1. Water tank volumes*

Water tanks are cubes or cylinders for this exercise. Write a program which allows the user to choose one of these two shapes (rejecting all others), input the size and calculate the volume using one of these formulae:

Volume of cube = $(\text{edge length})^3$
Volume of cylinder = $\text{Height} \times \pi \times \left(\frac{\text{diameter}}{2}\right)^2$

## We Learnt These in Chapter 21

*Statements*

**GOSUB** n to direct the ZX81 to a subroutine at line n.
**RETURN** at the end of a subroutine to direct the ZX81 back to the main program.
**STOP** to fence off the subroutines from the main program.

# 22

# Speeding up the Input

So far, to input a number or a string, we have had to stop the program, type it in and then press **NEWLINE** to go on. A new function, **INKEY$**, allows us to do this more quickly and smoothly, but it does have some limitations — for a start it needs the ZX81 in **SLOW** mode.

When the ZX81 meets **INKEY$**, it instantly checks every key on the board. If one key is being pressed, with or without **SHIFT**, the corresponding character is put into a single character string variable labelled **INKEY$**. Try this for a start:

```
100 PRINT INKEY$ ;
```

A laborious way of printing?, wasn't it! You happened to be pressing **NEWLINE** at the time, which returns a ? character. Now we'll put **INKEY$** in a loop, to give you a chance to get your finger off **NEWLINE** and onto some other keys.

```
110 GOTO 100
```

Have fun pressing lots of keys, but remember that for each character printed on the screen, ZX81 has checked the whole keyboard and put a new character into **INKEY$**. By the way, you can't press **SPACE** or £ — ZX81 reads these as **BREAK**.

I think you've grasped the idea that **INKEY$** is an ephemeral thing — whenever you mention **INKEY$** in a program it produces a new one, so we have to get up to various tricks to make use of it.

## Program branching

Here is a smooth, fast version of the program with a choice of branches, like the one in Chapter 19.

```
10  PRINT "GO ON OR STOP?"
20  PRINT,, "PRESS G OR S"
30  IF INKEY$="G" THEN GOTO 200
40  IF INKEY$="S" THEN GOTO 100
50  GOTO 30
100 PRINT,, "YOU STOPPED"
110 STOP
200 PRINT,, "YOU WENT ON"
```

Almost foolproof — press any key you like (except **BREAK**), and the ZX81 continues looping round lines 30/40/50 until G or S is pressed.

## A Permanent Record of INKEY$

In the program above we used **INKEY$** and then forgot it, but sometimes we need to make a permanent record like this:

```
10  PRINT "PRESS ANY KEY"
100 IF INKEY$<>"" THEN GOTO 100
110 IF INKEY$="" THEN GOTO 110
120 LET A$=INKEY$
130 PRINT "YOUR INKEY$ WAS "; A$
```

That needs a little explaining! Line 100 holds up the program till *no* key is being pressed — giving you a chance to get your finger off **NEWLINE**. Then line 110 stops the program until a key *is* pressed, and finally line 120 puts the **INKEY$** character into A$. Run the program, and then type in the commands:

**PRINT INKEY$** (it's gone)
**PRINT** A$ (it's still there)

With a few additions, we can use **INKEY$** to input strings of any specified length:

```
10  PRINT "TYPE A THREE LETTER WORD"
20  LET A$=""
100 FOR J=1 TO 3
110 IF INKEY$<>"" THEN GOTO 110
120 IF INKEY$="" THEN GOTO 120
130 LET A$=A$+INKEY$
140 NEXT J
150 PRINT "YOUR WORD WAS "; A$
```

Although you *can* juggle with **INKEY$** to input strings of unspecified length, this has little advantage over **INPUT**.

## How About Numbers?

If you use your program above and type in 123, the result *looks* like a number but is really the string '123' so you cannot do any maths operations on it. Luckily, ZX81 BASIC provides a function which turns suitable strings into numbers! Change and extend your program like this:

```
150 PRINT,, "STRING A$", "VAL A$"
160 PRINT A$, VAL A$
170 GOTO 10
```

Try putting in all sorts of strings, including some like these:

'123' '4.5' '6+7' '89A'

You have now discovered most of the rules for **VAL**:

(1) If a string consists entirely of characters which can be used in an arithmetical expression, **VAL** string will work out the expression and produce the answer. Suitable characters are:
Numbers
Names of variables previously defined
Operators
Full stop
Functions
Brackets.

(2) Any other characters will stop the program with a C/n or 2/n error code.

(3) You can keep a permanent record of **VAL** string by putting it into a number variable:
**LET** A=**VAL** A$

ZX81 also provides another function which exactly reverses **VAL**, namely **STR$**.

**STR$** number='number'
**STR$** 567 ='567'

This seemed a logical place to mention **STR$** — we'll use it later on.

Here's a well-known program for you to write, using **INKEY$** and **VAL**:

*Exercise 22.1. Number guessing*

Write a program to generate a random number between 10 and 99. Ask the user to type in a guess, and then tell him whether the guess is too low, too high or correct. With 1K of memory, you'll need to limit the guesses to about eight.

## We Learnt These in Chapter 22

*Functions*

**INKEY$** to allow a single character string to be input without stopping the program.
**VAL** to change a suitable string into a number.
**STR$** to change a number into a string.

# 23

# Son of Graphics

In Chapter 17 we drew simple pictures by using **PRINT** with graphics blocks in quotes. Each graphic block was made of four small squares (pixels) which could be black, white or grey.

## Plotting Points

We can use the statement **PLOT** X,Y to black in a single pixel anywhere on the screen. Try this demonstration program:

```
 2Ø  PRINT "PLOT X,Y DEMO"
 3Ø  PRINT,, "Ø TO 63 POINTS ALONG — THATS X"
 4Ø  PRINT,, " AND Ø TO 43 POINTS UP — THATS Y"
 5Ø  PRINT,, "WHAT IS X (Ø TO 63)? X= ";
 6Ø  INPUT X
 7Ø  PRINT X,,, "NOW Y (Ø TO 43)?"
 8Ø  INPUT Y
 9Ø  CLS
1ØØ  PLOT X,Y
11Ø  PRINT X; ",";Y
12Ø  INPUT A$
13Ø  CLS
14Ø  GOTO 5Ø
```

If you run the program it should explain itself. Notice how the **PRINT** position in line 11Ø is immediately after the **PLOT** position in line 1ØØ.

The **CLS** in line 13Ø is a bit of a sledgehammer to remove one point! We can take it out more delicately by using **UNPLOT**, the reverse of **PLOT**.

```
13Ø  UNPLOT X,Y
```

Notice how again the **PRINT** position follows right after the **UNPLOT** position.

## Plotting Lines

A single black blob is not a lot of use, but watch what happens when we put it into a loop:

```
10  FOR J=0 TO 63
20  PLOT J,0
90  NEXT J
```

The start of a picture frame! Now we need a bar along the top of the screen. Can you work it out? That's right:

```
30  PLOT J,43
```

The rest of the frame is up to you:

*Exercise 23.1. Vertical lines*

Add four more lines to the present program to draw the two verticals of the picture frame. There's a problem with your 1K of memory, by the way.

Oblique lines are not quite so successful, but let's see what we can do:

```
 10  FOR J=0 TO 43
 20  PLOT J,0
 30  PLOT J,43
 40  PLOT 0,J
 50  PLOT 43,J
 60  PLOT J,J
 70  PLOT J,43-J
100  NEXT J
```

Put in lines 20 to 70 one by one, and run after each addition to check which program line draws which line on the screen.

If you want, you can use **PLOT** in nested loops to black out whole slabs of the screen, though it's a little slow.

```
10  FOR J=0 TO 63
20  FOR K=0 TO 41
30  PLOT J,K
```

```
40  NEXT K
50  NEXT J
```

We can wipe the whole screen as usual with:

```
60  CLS
```

However, if we halve the rectangle to release more memory, we can wipe it out in a more leisurely way — the Danish Blue cheese method:

```
10  LET K=0
20  FOR J=0 TO 43
30  FOR K=0 TO K
40  PLOT J,K
50  NEXT K
60  NEXT J
70  LET X=RND*43
80  UNPLOT X, RND*(X+1)
90  GOTO 70
```

## Mixing Print With Graphics

As we know, the **PRINT** position follows immediately after the last **PLOT** or **UNPLOT** point, which can be inconvenient. Luckily ZX81 will let us print anywhere we like on the screen by using:

**PRINT AT** line number, column number; string or number

Line numbers go from 0 at the top of the screen to 21 at the bottom. Column numbers are the same as **TAB** numbers, 0 to 31. Here is a demonstration game to get you used to the **PRINT AT** positions:

```
 10  PRINT TAB 7; "PRINT AT DEMO"
 20  PAUSE 200
100  CLS
110  PRINT "PUT A FINGER ON THESE POINTS"
120  PAUSE 200
130  LET L=INT (RND*22)
140  LET C=INT (RND*32)
150  CLS
160  PRINT "PRINT AT "; L; ","; C
170  PAUSE 400
180  PRINT AT L, C; "*"
190  GOTO 120
```

Remember that any further printing follows right after the **PRINT AT** item, according to the usual punctuation rules. If you want to go

back to the top of the screen, you'll have to use another **PRINT AT**.
**PRINT AT** is also useful for rubbing out bits of the screen — all you need to do is to print spaces at the positions you want to rub out:

```
100  FOR J=0 TO 21
110  PRINT AT J, J; J
120  NEXT J
200  PRINT AT 0, 4; "RUBBING OUT THE ODD NUMBERS"
210  FOR J=1 TO 21 STEP 2
220  PRINT AT J, J; "  "
230  NEXT J
```

Here are some simple exercises using **PLOT** and **PRINT AT**:

*Exercise 23.2. Visiting card*

Write a program to print a black visiting card in the centre of the screen, with your name and address in inverse letters.

*Exercise 23.3. 'On we go' subroutine*

A very useful subroutine to stop the program until **NEWLINE** is pressed. Print the prompt 'PRESS NEWLINE' at the bottom right of the screen, put in an **INPUT** pause, then wipe the bottom line only and **RETURN**.

## Graphics with the ZX Printer

The simple graphics of Chapter 17, in which graphic block arrangements are printed line by line, can be recorded on paper by simply changing **PRINT** statements to **LPRINT**. On the other hand, **LPRINT AT** will not work, it behaves more or less like **LPRINT TAB**. If you think about it, **PRINT AT** may be asking the ZX81 to go back along a line, or to move up to some line previously printed — the ZX Printer cannot cope with this! Nor will **PLOT** produce any result with the ZX Printer — what can we do to make a permanent record of our beautiful graphics?
We met the answer in Chapter 15, simply use the keyword **COPY**, either as a command or a statement, and the ZX Printer will make a faithful copy on paper of the current screen contents — **PLOT** points, **PRINT AT** items and all.

## We Learnt These in Chapter 23

*Statements*

**PLOT** X,Y to black in a pixel at the coordinates X,Y.
**UNPLOT** X,Y to rub out the pixel at the coordinates X,Y.
**PRINT AT** line number, column number; to print an item at any position on the screen, regardless of anything printed before.
**COPY** to make a permanent record on paper of the current screen contents, including all graphics and **PRINT AT** items.

*Anything else*

Loops containing **PLOT** to draw lines and blocks on the screen.
**PRINT AT** line, column; "        " to rub out sections of the screen.

# 24

# Playing with Strings

There is a theory that, given infinite time and paper, a set of chimpanzees would eventually type the complete works of Shakespeare. Let's try:

```
 10 RAND
 90 CLS
100 FOR J=1 TO 80
200 FOR K=1 TO INT (RND*8+1)
210 LET A=INT (RND*26+38)
220 PRINT CHR$ A;
300 NEXT K
310 IF RND<.07 THEN PRINT ".";
350 PRINT " ";
400 NEXT J
500 PRINT
510 PRINT,, "PRESS NEWLINE"
520 INPUT A$
530 GOTO 90
```

I suppose the theory is alright, but you'll need a lot of patience! The important lines to look at are 210, which generates a random number between 38 and 63, and line 220, which prints a new function.

**CHR$** A is the character which has the code number A, and if you look on page 182 of your operating manual, you will find that 38 to 63 are the code numbers for A to Z.

We can use **CHR$** to see every character in the ZX81 repertoire, all 255 of them:

```
10 LET K=0
20 FOR J=1 TO 8
```

```
 3Ø  FOR K=K TO K+7
 4Ø  PRINT CHR$ K;"  ";
 5Ø  NEXT K
 6Ø  PRINT,,
 7Ø  NEXT J
 8Ø  PRINT,,"PRESS NEWLINE"
 9Ø  INPUT A$
1ØØ  CLS
11Ø  GOTO 2Ø
```

You will see a whole mixture of graphic blocks, numbers, symbols, letters, keywords, functions, and inverse characters. The second page consists mostly of ?s — these are either unused characters or commands like **NEWLINE** which print nothing on the screen.

Two more useful string functions are **CODE** and **LEN**, and this program makes it pretty clear what they do:

```
1Ø  PRINT "INPUT SOME WORDS"
2Ø  PRINT "W$";TAB 1Ø;"CODE W$";TAB 2Ø;" LEN W$"
3Ø  INPUT W$
4Ø  PRINT,,W$;TAB 1Ø;CODE W$;TAB 2Ø;LEN W$
5Ø  GOTO 3Ø
```

Run the program and input words like APPLE, ANT, A, BEETLE, BUN, B. Try words consisting of spaces, and also the empty string. By now you will have discovered that **CODE** of a string gives 'the code number of the first character in that string'. **LEN** of a string is equal to 'the number of characters (including spaces) in the string' — in other words, length of the string.

## Chopping Up Strings

ZX81 has a simple but very useful way of slicing strings. As soon as a string or a string variable is typed in, its characters are each numbered, starting at 1, continuing 2, 3, . . ., and ending with the last character which has the same number as **LEN**. For example:

```
LET Z$="CAKE"         LEN Z$=4
Z$(1)="C"  Z$(2)="A"  Z$(3)="K"  Z$(4)="E"
```

We can slice out any characters we like from a string by using the function:

```
string ( m TO N )
```

Try it out with this program:

```
1Ø  PRINT "SLICING SPORTSMAN"
```

```
 2Ø  LET A$="SPORTSMAN"
1ØØ  PRINT "INPUT TWO NUMBERS, 1 TO 9"
11Ø  PAUSE 3ØØ
12Ø  CLS
13Ø  INPUT M
14Ø  INPUT N
15Ø  PRINT,,"SPORTSMAN(";M;" TO ";N;")=";A$ (M TO N)
16Ø  GOTO 13Ø
```

If you input various pairs of numbers, you'll find that the first number must not be less than 1, and the second number must not be greater than 9 (**LEN** "SPORTSMAN"=9).

You can if you wish chop out part of one string, and put into another string variable for future use. Type these commands, after running the program above:

```
LET B$=A$ (2 TO 8)
PRINT A$,B$
```

You may only require a single character from your original string, and in this case you can drop the **TO**. Try typing a few commands like:

```
PRINT A$(1)        PRINT A$(2)        PRINT A$(9)
```

Again, the lower limit is 1 and the upper limit is **LEN** A$. Let's use this method to print your choice of word in all sorts of ways:

```
 1Ø  PRINT "INPUT ANY WORD"
 2Ø  INPUT W$
 3Ø  CLS
1ØØ  FOR J=1 TO LEN W$
11Ø  PRINT W$(J);" ";
12Ø  NEXT J
```

That was straightforward, but now change line 1ØØ to:

```
1ØØ  FOR J=LEN W$ TO 1 STEP -1
```

And now let's print your word in inverse letters. We make use of the fact that the **CODE** of an inverse letter is 128 higher than the **CODE** of the original letter:

```
11Ø  PRINT TAB 1;CHR$ (CODE W$(J)+128)
```

Sorry, we've got it upside down now! Add these lines to march the letters into their correct places:

```
2ØØ  FOR J=1 TO LEN W$
21Ø  FOR K=Ø TO J-1
```

```
220 PRINT AT LEN W$-J+K,K+1;CHR$ (CODE W$(J)+128)
230 PRINT AT LEN W$-J+K-1,K;" "
240 NEXT K
250 NEXT J
```

Here's an exercise in which you can try out slicing for yourself:

*Exercise 24.1. Ants*

Ants are words which begin with 'ANT' or end with 'ANT'. Write a program which asks for words to be input, checks them, lists them on the screen if they are ants, or rejects them if they are not.

## We Learnt These in Chapter 24

*Functions*

**CHR$** n , equal to the character which has the code number n.
**CODE** s , equal to the code number of the first character in string s.
**LEN** s , equal to the number of characters in string s.
s (m **TO** n) , equal to a slice from string s, from the m th character to the n th character.
s (n) , equal to the n th character from string s.

# 25

# In Glorious Array

## Dummy Variables

We have learnt how to do all sorts of things to numbers and strings. Sometimes we need to keep a record of the original number or string, using a dummy variable, so that we can refer to it later. Here's a simple example.

```
 10 LET B$=" "
100 PRINT "TYPE A WORD"
110 INPUT A$
120 CLS
130 PRINT " YOU TYPED ";A$
140 IF A$=B$ THEN GOTO 300
200 PRINT "THATS A CHANGE"
210 PRINT "IT WAS ";B$;" LAST TIME"
220 GOTO 400
300 PRINT "BORING — SAME AS LAST TIME"
400 LET B$=A$
410 GOTO 100
```

We have an **INPUT** loop round lines 100 to 410, and variable A$ is changed each time we go round the loop. However, in line 400 we put A$ into a dummy variable B$, so that we can compare this with the new A$ next time round. We can do exactly the same with number variables, of course.

## Arrays of Numbers

We know how to keep a permanent record of one number by giving it a variable name. Now suppose we want to keep a record of a *set of* *numbers* which have something in common — for example, in a dice throwing experiment, the number of ones, twos, threes, fours, fives and sixes we have thrown. We can do this by setting up a *single dimension array*, using the statement **DIM**:

```
10  DIM D(6)
```

If we run this program, we have now created six variables:

D(1)  D(2)  D(3)  D(4)  D(5)  D(6)

and each one of them has been set to zero. Check this by typing commands like: **PRINT** D(3).

An array must have a name consisting of a single letter. It can have as many members as you like, subject to available memory, and each member has a different subscript number in brackets, starting with 1, to distinguish it from all the others. Note that D(0) does not exist.

On with the program — we'll randomise and then throw the dice sixty times:

```
 20  RAND
100  FOR J=1 TO 60
110  LET T=INT (RND*6+1)
200  NEXT J
```

Now for the cunning bit — this is where the subscripts come in. If we throw a five, we need to add one on to D(5), the total of fives thrown.

```
120  LET D(T)=D(T)+1
```

If T happens to be a five, then this is the same as saying:

```
LET D(5)=D(5)+1
```

The next T might be three, and we would add one on to D(3), and so on. Now we need to print out our results:

```
 90  PRINT "WAIT"
300  PRINT "60 DICE THROWS",,,,
310  FOR J=1 TO 6
320  PRINT TAB 5;D(J);" ";J;"S",,
330  NEXT J
```

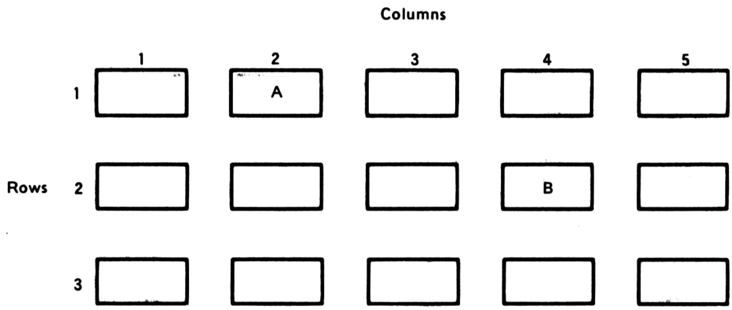
Finally we can stop to display the results, and then back to **DIM** in line 10 to reset all the array variables to zero and start again:

```
400  PRINT "PRESS N/L FOR MORE"
410  INPUT A$
420  GOTO 10
```

Later on, with moving graphics, we'll rewrite this program to give a compulsive race game.

## Multi-Dimension Arrays

Imagine that we are letting out fifteen caravans to holidaymakers in the month of August. We arrange the vans in three rows, and each row has five vans in it.




We can name a van uniquely by giving its ROW and then its COLUMN. For example, van A is (1,2) — ROW 1 and COLUMN 2. Van B is (2,4) and so on.
ZX81 will do exactly the same operation using **DIM**:

```
1Ø DIM V(3,5)
```

Run the program, this time we have set up 15 variables, arranged like the caravans above in a 3×5 array, each one set to zero:

V(1,1)=Ø    V(1,2)=Ø    and so on.

Now we can write a caravan booking program, if we say that:

V(m,n)=Ø means a vacant van

and V(m,n)=1 means a booked van.

```
 2Ø PRINT "WHICH VAN DO YOU WANT?"
 3Ø PRINT,,"WHICH ROW (1 TO 3)? ";
 4Ø INPUT R
 5Ø PRINT R
 6Ø PRINT "WHICH COLUMN (1 TO 5)? ";
 7Ø INPUT C
 8Ø PRINT C
 9Ø PAUSE 2ØØ
1ØØ IF V(R,C)=1 THEN GOTO 2ØØ
```

```
110  PRINT,,"VAN (";R;",";C;") IS FREE"
120  LET V(R,C)=1
130  PRINT,,"I HAVE BOOKED IT FOR YOU"
140  PRINT,,"NEXT CUSTOMER PLEASE PRESS N/L"
150  GOTO 220 .
200  PRINT,,"SORRY, VAN (";R;",";C;") IS TAKEN"
210  PRINT,,"PRESS N/L TO TRY ANOTHER"
220  INPUT A$
230  CLS
240  GOTO 20
```

We are not limited to two dimensions, except by our available memory. Each of the caravans could be let out for each of the twelve months, needing a 3×5×12 array. This program would start

```
10  DIM V(3,5,12)
```

but you will have to write the rest!
Here is an array problem for you to try:

*Exercise 25.1. Simple cows and bulls*

This is the well-known game in which you have to guess a four-digit number. After your guess you are told how many of the digits you guessed exactly right (bulls). The general scheme is this:

Generate four random digits between 1 and 6 and put them in a single dimension array.
Ask the player to guess the number.
Input his guess as a string variable.
Compare the digits of his guess, one by one, with the digits in your array (remember **VAL**!).
Tell him how many bulls he scored.

## We Learnt These in Chapter 25

*Statements*

**DIM** to reserve space for an array of numbers and to set them all to zero.
e.g. **DIM** A(n) for a single-dimension array with n members.
**DIM** A(m,n) for a two-dimension array with m×n members.

*Anything else*

Dummy variables to provide a memory for variables which would otherwise be lost.

# 26

# Arrays of Strings

We found out about arrays of numbers in the last chapter. Arrays of strings are set up in much the same way. We already know that a string variable is equivalent to a single-dimension string of characters. For instance:

```
20  LET A$="CAT"
```

Run the program and type these commands:

```
PRINT A$(1)    (this gives C)
PRINT A$(2)    (this gives A)
PRINT A$(3)    (this gives T)
```

If we put in a **DIM** statement:

```
10  DIM A$(5)
```

we have merely reserved space for one five-character string called A$, set all the characters to empty spaces, and then inserted the string "CAT". We can check this by adding:

```
30  FOR J=1 TO 3
40  FOR K=1 TO 5
50  PRINT A$(K)
60  NEXT K
70  NEXT J
```

There are five spaces available, but we have only filled three of them. Now we'll change the **DIM** statement — better type **NEW** and start again.

```
10  DIM B$(7,5)
```

This time we have reserved space for an array of seven strings, each one of five characters as before. Let's start putting in some actual strings:

```
20  LET B$(1)="CAT"
30  LET B$(2)="DOG"
40  LET B$(4)="MOUSE"
```

and then printing them out:

```
100  FOR J=1 TO 7
110  PRINT B$(J);
120  NEXT J
```

Notice that in defining members of this string array (lines 20 to 40), and in using them (line 110), we only type one subscript number, to say which of the strings we are talking about. The second subscript number is only used once — in the **DIM** statement — to fix the maximum length of each member of the array. What happens if we try to put in a longer string than we have allowed for?

```
50  LET B$(5)="ELEPHANT"
```

ZX81 makes no objection, it merely refuses to print any characters after the first five! If you really need more than "ELEPH", you'll need to change the **DIM** statement. Maybe this is why the code on my driving licence refers to a fellow called "NORMA"!

## Multi-Dimension String Arrays

Just as easy, but a bit heavy on memory. Type the commands **NEW** and then **DIM** C$(4,3,8). This makes room for an array of 4×3 strings. Once again, the last subscript number is to fix the maximum length of the strings, and only appears in the **DIM** statement. When defining or using members of the array, we only use the first two numbers.

```
LET C$(2,3)="ELEPHANT"
PRINT C$(2,3)
```

## Naming String Arrays

A string array may have any single letter name, followed by $ and then the subscript numbers. A name like A$, for instance, can only be used for *one* string array. If you write a second *DIM* A$(m,n,..) you simply cancel the original **DIM** and replace it with this new one. But you can, if you want to, use all of these variables in a single program:

| | |
|---|---|
| A (number variable) | A$ (string variable) |
| A (n,. . .) (number array) | A$(n,. . .) (string array) |

## Chopping Members of a String Array

Assuming that you still have your C$(2,3) = "ELEPHANT" in memory, try typing these commands:

**PRINT** C$(2,3,1)
**PRINT** C$(2,3,2)
**PRINT** C$(2,3,8)

So obviously if you type in one extra subscript number, you simply pull that particular character out of the string variable. If you want larger slices, do it like this:

**PRINT** C$(2,3)(2 **TO** 7) or **PRINT** C$(2,3,2 to 7)

Now for some exercises using string arrays:

*Exercise 26.1. Test results*

You have a class of six children — put their names into a string array. Write a program which asks for:

The name of the test.
The maximum possible mark.
Each child's mark (use a number array).

The output should consist of a title and a list of names and percentages.

*Exercise 26.2. One-armed bandit*

Set up a string array containing six fruit machine items (bell, lemon, etc). Generate three random numbers and use these to print three of the fruits across the screen. Check for a jackpot — three fruits the same.

## We Learnt These in Chapter 26

*Statements*

**DIM** A$(m,n. . .) to set single or multi-dimension string arrays. The last (extra) subscript number fixes the maximum length of each member of the array.

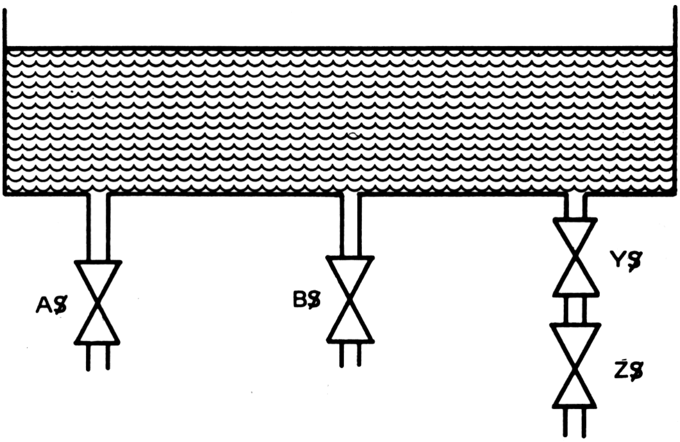
*Anything else*

Slicing out parts of string array members.

# 27

## Very Logical

We started this in Chapter 12 with **IF . . . THEN** — now let's take it a little further. Here is a picture of a water tank with some pretty weird plumbing. It has four water taps labelled A$, B$, Y$ and Z$.




It's a simple chemical engineering problem. We have to write a program to warn us when water is running away through an open tap. We'll deal with A$ first:

```
 1Ø  PRINT "SET YOUR TAPS NOW",,"O=OPEN   S=SHUT"
 2Ø  PRINT,,"A$ is? ";
 3Ø  INPUT A$
 4Ø  PRINT A$
 15Ø IF A$= "O" THEN GOTO 1ØØØ
 2ØØ PRINT "ALL OK"
 21Ø PRINT AT 21,Ø;"PRESS N/L FOR MORE OR S TO STOP"
```

```
 220  INPUT X$
 230  IF X$="S" THEN STOP
 240  CLS
 250  GOTO 10
1000  PRINT
1010  FOR J=1 TO 5
1020  PRINT "DING DONG"
1030  NEXT J
1040  PRINT,,"WATER RUNNING OUT"
1050  GOTO 210
```

Run the program, open and close A$, and make sure the alarm is working properly. Now for the B$ tap.

```
50  PRINT "BS IS? ";
60  INPUT B$
70  PRINT B$
```

Now we need a line like 150 to test whether B$ is open, but wait a bit . . . we can *include* B$ in line 150:

```
150  IF A$="0" OR B$="0" THEN GOTO 1000
```

Did it work? Sure did! The alarm goes off if either A$ or B$ is left open. Two more taps to go now:

```
 80  PRINT "Y$ IS? ";
 90  INPUT Y$
100  PRINT Y$
110  PRINT "Z$ IS? ";
120  INPUT Z$
130  PRINT Z$
```

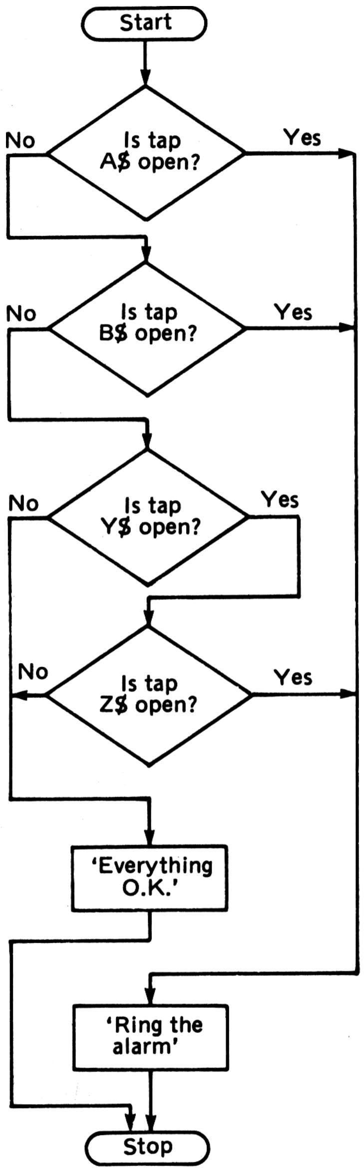
We'll need to think hard about this — if either one of taps Y$ and Z$ is closed then we're still holding water. We only need the alarm if they are both open, so:

```
160  IF Y$="0" AND Z$="0" THEN GOTO 1000
```

Run the program again, and open and shut all the taps to test it out thoroughly. Then replace lines 150 and 160 with one single gloriously logical line:

```
150  IF A$="0" OR B$="0" OR Y$="0" AND Z$="0" THEN
       GOTO 1000
```

which works just as well. There is a flowchart for this program shown on the next page.




## Priorities

These long logical statements need clear thinking. They depend on the fact that the ZX81 tests the statements in a specific order, giving

**AND** priority over **OR**. As with arithmetical expressions, we can change the priority, or give it emphasis, by adding brackets. For example this line:

15Ø **IF** A$="0" **OR** B$="0" **OR** (Y$="0" **AND** Z$="0")
**THEN GOTO** 1ØØØ

has exactly the same effect as before, but it is easier to understand.
This is the time to mention that ZX81 has logical **NOT** available, though it seems to be superfluous because:

IF NOT A=B is the same as IF A<>B
IF NOT X> =Y is the same as IF X<Y
and so on.

Also there are logical values which go with **AND, OR, NOT** — these are dealt with in Chapter 10 of the ZX81 operating manual. They should be considered as time- and memory-savers for advanced programmers, they do not do anything which cannot be done with statements already covered in this book.
Now try out your own logic:

*Exercise 27.1. Water tank mark 2*

We've scrapped the old plumbing system — always thought it was rubbish! The tank is now fitted with a single branched outlet pipe fitted with three taps A$, B$, and C$. Change the input lines to fit these taps, and then type in this new logic line:

15Ø **IF** A$="0" **AND** (B$="0" **OR** C$="0") **THEN GOTO** 1ØØØ

Run the program, open and shut the various taps, and deduce the new layout of pipes and taps.

## We Learnt These in Chapter 27

Logical statements **AND, OR** to use with the **IF . . . THEN** statement.
**AND** has priority over **OR.**
Brackets to change or emphasise priority.

# 28

# Graphics Ride Again!

This chapter is concerned with moving graphics, which must be run in **SLOW** mode on the ZX81. Users of ZX80s will have to skip on to the next chapter.

## Flashing Lights

If we want to emphasise special words on the screen, we can use inverse graphics, or flash the words, or both as in this subroutine:

```
 100  GOSUB 1000
 900  STOP
1000  REM ** CORRECT ANSWER
1010  FOR J=1 TO 20
1050  PRINT AT 15,20;"RIGHT"       (inverse characters)
1100  PRINT AT 15,20;"     "       (five spaces)
1200  NEXT J
```

As it stands, this program gives a fast flickering effect, it needs slowing down. Either insert **PAUSE** statements, or for a really smooth display use empty loops:

```
1060  FOR K=1 TO 10
1070  NEXT K
1110  FOR K=1 TO 10
1120  NEXT K
```

## Bouncing Balls

For a start we'll draw bits of floor and ceiling for the ball to bounce between:

```
100  FOR J=20 TO 40
```

```
110 PLOT J,1
120 PLOT J,42
130 NEXT J
```

Next we'll print the ball, fairly near the ceiling:

```
 10 LET V=1
200 PRINT AT V,15;"0"
```

Now to move the ball down the screen:

```
 20 LET VV=1
150 LET V=V+VV
400 GOTO 150
```

A nasty looking trail of 0s — we'll have to rub them out as we go.

```
300 PRINT AT V,15;" "
```

A bit better that time, but the ball seems to be made of lead! To make it bounce we must change the sign of VV at the floor, and then again at the ceiling:

```
250 IF V=20 OR V=1 THEN LET VV=-VV
```

Success! It will bounce until you switch off or press **BREAK**.

Now we'll extend the program into two dimensions, to give the rudiments of a TV game. The idea is the same, but this time we are changing both the line number and the column number each time round the loop. We shall have to bounce inside a small rectangle to avoid running out of memory, and we start the ball at a random position:

```
 10 LET VV=1
 20 LET HH=1
 30 LET V=INT (RND * 13+1)
 40 LET H=INT (RND * 19+1)
210 FOR J=1 TO 42
220 PLOT J,42
230 PLOT J,13
240 NEXT J
250 FOR J=14 TO 41
260 PLOT 1,J
270 PLOT 42,J
280 NEXT J
300 LET H=H+HH
310 LET V=V+VV
320 PRINT AT V,H;"0"
330 IF H=20 OR H=1 THEN LET HH=-HH
```

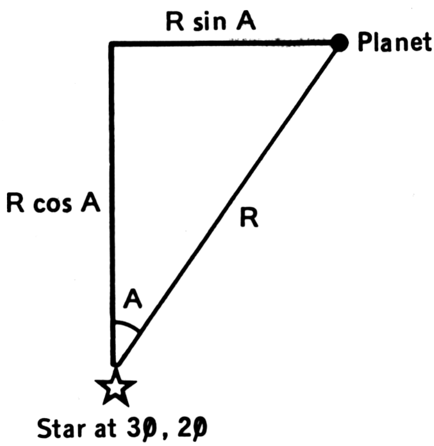
```
340  IF V=14 OR V=1 THEN LET VV=-VV
350  PRINT AT V,H;" "
360  GOTO 300
```

## Circling Satellites

This program prints a star in the middle of the screen, and then uses **PLOT** to put a planet into orbit:

```
 10  PRINT "RADIUS? 3 UP TO 20"
 20  INPUT R
 30  PRINT AT 11,15;"*"
 40  LET A=0
100  UNPLOT 30+R * SIN A,20+R * COS A
110  LET A=A+.2
120  PLOT 30+R * SIN A,20+R * COS A
130  GOTO 100
```

This diagram shows you how the trigonometry works:




If you delete lines 100 and 110 and add these lines:

```
 40  FOR A=0 TO 2 * PI STEP .05
130  NEXT A
```

your program will draw a circle (of sorts).

## Darting Arrows

Here is a three-line program which pushes an arrow across the screen:

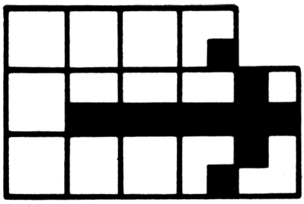
```
100  FOR J=0 TO 27
110  PRINT AT 15,J;"   ▗";TAB J;" ▄▄▄▙";TAB J;"   ▗▘"
120  NEXT J
```

The graphics are hard to sort out, but this diagram will help:

PRINT AT 15,J;

TAB J;

TAB J;



There are two important points here: (1) The technique of using **TAB** J to print an item exactly under a previous item printed at position J on the line. (2) The use of a space at the beginning of the three literal strings which make up the arrow — these automatically rub out the remains of previous arrows as we move across the screen.

## Trundling Tortoises

This combines the dice-throwing program from Chapter 25, with the arrow-shooting technique above, to push five tortoises across the screen.

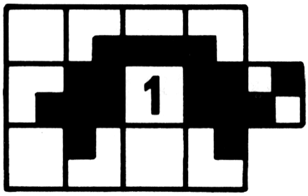
```
 10  RAND
 20  DIM D(5)
100  CLS
110  PRINT "ZX81 TORTOISE RACE"
200  LET T=INT (RND * 5+1)
210  LET D(T)=D(T)+1
310  PRINT AT T * 3,D(T);" ▄▄▄ ";TAB D(T);"▗█ ";T;"█▛";
     TAB D(T);"▛▜"
320  IF D(T)<27 THEN GOTO 200
400  PRINT AT 21,20;"NO. ";T;" WINS"
410  INPUT A$
420  RUN
```

A tortoise is printed and moved across just like the arrow (but not quite so fast). This diagram will make the graphics clearer:

**PRINT AT** T * 3,D(T)

**TAB** D(T)

**TAB** D(T)




Notice how the tails leave a trail of dashes as the tortoises move. If you don't like this, you will have to include a space just ahead of the tail, and shorten the race by one character.
Perhaps you would like to try your own hand at some graphics problems.

*Exercise 28.1. Flasher*

Write a subroutine to reward the winner of one of your games — flash the 'WINNER' at the bottom right of the screen ten times, leaving it switched on at the end.

*Exercise 28.2. Rubber ball*

We saw a program for an everlastingly bouncing ball. Now write a program for a real ball, bouncing vertically, the bounces gradually getting smaller, and finally coming to rest on the floor. This is a hard one — you will need an inner loop to bounce the ball up and down within certain limits, and an outer loop to gradually reduce the upper limit and make the bounces smaller.

*Exercise 28.3. Lunar module*

We made arrows and tortoises move across the screen. Your problem is to design a little moon-landing module — use any of the characters you like — and move it down the screen onto the moon's surface. It will look better if it is seen to decelerate as it descends!

# 29

# What a Memory!

## Binary Arithmetic

We all know that computers work in binary (base 2) arithmetic. Like most microcomputers, the ZX81 contains a large number of memory cells or *bytes*, each containing an 8-bit number. Here's how to make a working model byte:

Cut a post card in half, longways, mark it out like this and cut along the dashed lines:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 128 | 64 | 32 | 16 | 8 | 4 | 2 | 1 |

Now fold up all the eight tabs to cover the 1s, and write 0s on the exposed faces like this:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Each bit in your byte can now have the value 0 (folded up) or 1 (hanging down). The decimal value of the number in the byte is found by adding the decimal numbers hanging down:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 |
| | 64 | | | 8 | 4 | | 1 |

Here the binary number in the byte is 01001101, equal to the decimal number 64+8+4+1=77.

The smallest decimal number in a byte is of course 0 (all folded up) and the largest is 255 (all hanging down). So the memory cells of the ZX81 are full of numbers between 0 and 255, and these may represent numbers, characters, instructions, and so on. Larger numbers than 255 have to go into two or more bytes, and when we define a variable by:

```
LET A=1
```

the ZX81 sets aside five bytes to contain all possible information on A (size, position of decimal point, sign) plus whatever bytes are needed for the variable name.

## ZX81 Memories

The ZX81 memory comes in two parts. The ROM (read only memory) consists of 8K bytes ($1K=2^{10}=1024$ bytes), which contain all the fixed instructions needed to convert BASIC into binary code, and to tell the ZX81 what to do at all times. ROM is permanent, you can find out what is in any byte of ROM but you cannot change it.

The second part is called RAM (random access memory), which consists of 1K byte (1024 bytes numbered from 16384 to 17407). RAM contains all the items which change from program to program — the system variables, your actual program, the display file and the number and string variables. You can find out the contents of any RAM byte, and you can also change it.

To make full use of your ZX81 you will need the 16K RAM pack. This is a box the size of a pack of cigarettes which clips onto the edge connector at the back of the ZX81. This increases your RAM to a total of 16K or 16383 bytes (see Appendix 5).

## What's In that Byte?

To find the contents of a byte of ROM or RAM which has the address number n, we use the function PEEK n. Here is an example:

```
100 LET F=PEEK 16396+256 * PEEK 16397
110 PRINT "DISPLAY FILE STARTS","AT BYTE ";F
```

What is happening? Well, the first slice of RAM contains the system variables — it is always a fixed size from 16384 up to 16509. The next slice contains your program, which of course can vary in size, followed immediately by the display file (the record of what will be printed on the screen when the program stops). One of the system variables is the starting address of the display file — the ZX81 needs to know this. Being a five-digit number it is contained in two bytes, 16396 and 16397.

Run the program, note the start of the display file, and then add another line of program, say:

```
120 PRINT
```

If you now run again, you will find that the display file has moved along six bytes, the amount of space needed for the new program line. Now, let's find out what is actually in the first ten bytes of the display file.

```
130 FOR J=0 TO 9
140 PRINT PEEK F+J
150 NEXT J
```

Well, I did warn you that bytes of ROM and RAM simply contain numbers up to 255! Who can remember the function to turn codes into characters? Well done!

```
140 PRINT CHR$ PEEK (F+J)
```

I did say that we could change the contents of any byte of RAM — it is not to be recommended unless you are sure you know what you are doing. The statement is:

**POKE** m,n

m is the address of the byte we are changing
n is the new value we are putting in (between 0 and 255 of course).

Let's poke an asterisk (code 23) into the top line of the screen display:

```
125 POKE F+5,23
```

Run the program again and make sure that it worked. You are well on the way to finding out how the ZX81 organises its memory!

## Advanced Programming

You can write good BASIC programs without ever using a **PEEK** or a **POKE**, but eventually you will find that they let you do things which are otherwise impossible. You will also want to use the **USR** function to write machine code routines — they run faster and use less memory than BASIC. You will need to read your ZX81 operating manual very carefully (Chapters 25 to 28), and buy a more advanced book on programming. Good luck!

## We Learnt These in Chapter 29

*Statements*

**POKE** m,n   to put the value n into the byte at address m.

*Functions*

**PEEK** m   gives the contents of byte m as a decimal number.

*Anything else*

ZX81 memory, 8K of ROM, 1K of RAM plus plug-in expansion to give 16K total RAM.

# 30

# Debugging Your Programs

You are doing well if you can write a program of any length which runs properly first time. You are more likely to find that there are errors or 'bugs' to be removed.

## Syntax Errors

Generally the ZX81 will not allow this kind of mistake. Leave out a quote or a bracket, mix up string and number variables, or commit any other sin in syntax, and the ZX81 will put up the S cursor and stop the line from being entered. Make sure your lines do enter, by the way, since you can waste a lot of time typing a new line onto the end of one with a syntax error.

## Errors which Stop the Program

Even if every line has entered correctly, the program may stop running because of some other error. Here the ZX81 helps by printing a report code showing the line number and the type of error that caused the crash. These codes are all listed in Appendix B of your ZX81 operating manual, and often it is obvious what must be done to put things right. Here are a few where the remedy is not quite so obvious.

*Code 2/n. Undefined variable*

All variables must be defined by one of these statements:

**LET** **INPUT** **FOR** (loop control variables) **DIM** (arrays)

*Code 4/n. No more room in memory*

Common mishap with 1K of RAM which does not go very far, especially if you are using graphics and arrays. Here are some ideas for saving memory, remembering that your RAM is used up by your program and also by your variables and display file.

(1) Cut down the number of variables. Shorten arrays, cut out surplus dummy variables, use the same name for more than one variable in different parts of the program if possible.
(2) Shorten literal strings and string variables, use abbreviations.
(3) Remove **REM** lines.
(4) Look out for duplicated operations — put them into loops or subroutines.
(5) Reduce the amount of screen used for printed output and graphics display.
(6) Consider splitting the program — remember that variables generated in one part can be used in another part.
(7) Start saving for your 16K RAM pack!

*Code 5/n. Screen full*

**CONT** clears the screen and lets your program continue. In the long run you'll have to tidy things up by reducing the output, or inserting a pause followed by **CLS**, or using **SCROLL**.

## Errors Which Do Not Stop the Program

Programs often appear to run successfully, but print out rubbish. Remember the old saying that there are no bad computers, only bad programs. Sometimes it's clear that an output is not sensible, at other times it's not so obvious and you must check carefully. Here are some ideas:

(1) Check your program by putting in data with a known answer.
(2) Check your answer with a hand calculator.
(3) Look for punctuation errors when you are having trouble with tables of results or graphics.
(4) Try out conditional statements by putting in data which does, then does not, satisfy the condition.
(5) Follow the course of your loops (especially nested loops) carefully, preferably using a flowchart.

(6) Put in temporary **PRINT** lines to print the value of your variables at different points in the program.
(7) Break up your program with temporary **STOP** lines and check the different parts separately. Use command **PRINT** to look at your variables, then **CONT** to go on with the program.
(8) It may be useful to use **CLEAR**, as command or statement, to delete all variables before putting in new values of your choice.
(9) Check later parts of your program by using **RUN** n or **GOTO** n to start running your program at line n. Remember that **RUN** clears all variables, **GOTO** does not.

# Appendix 1

## ZX81 BASIC in 8K ROM

A complete list of all the instructions in BASIC available from the ZX81 keyboard.

| | |
|---|---|
| s | represents a literal string within quotes, or a string variable. |
| n, m, p | represent numbers, variables or expressions. Where whole numbers are required for n, m, p (as in **PLOT** n,m) the ZX81 rounds off to the nearest whole number (e.g. 10.4 rounded to 10, 10.6 to 11, and 10.5 to 11). |

### Commands Used in Writing and Editing Programs

| | |
|---|---|
| **EDIT** | brings a line (indicated by the current line pointer) to the bottom of the screen for editing, and deletes anything already on the bottom of the screen. |
| ⇧ ⇩ | move the current line pointer one line up or down. |
| ⇦ ⇨ | move the cursor one character to the left or right, without affecting text. |
| **FUNCTION** | changes the cursor to [F]. The next key pressed puts the corresponding function on the screen and returns the cursor to [L]. |
| **GRAPHICS** | changes the cursor to [G], to obtain graphic blocks and inverses of letters, numbers and some other characters, for use in strings. Press **GRAPHICS** again to return cursor to [L]. |
| **LIST** | displays as much program as possible starting with the first line, and puts the current line pointer above the first line. |
| **LIST** n | displays as much program as possible starting with |

| | |
|---|---|
| | line n and puts the current line pointer at line n. |
| **NEWLINE** | (1) transfers a numbered and valid line from the bottom of the screen into the program. |
| | (2) makes the ZX81 execute any command typed on the bottom of the screen. |
| | (3) clears the screen after a run and restores previous listing of program. |
| **RUBOUT** | deletes the character or keyword to the left of the cursor. |
| **SHIFT** | pressing **SHIFT** plus any other key returns the character printed on that key in red. |

## System Commands

Keyword instructions which are not part of the program, but are keyed in and executed once with **NEWLINE**. ZX81 accepts any keyword as a command, but **INPUT** gives an error Ø/8 and some others don't often make sense. All commands except **BREAK, STOP** and **COPY** clear the screen before they are executed.

| | |
|---|---|
| **BREAK** | (1) stops the ZX81 while it is working. Report code shows where the program stopped, and any output is displayed. |
| | (2) stops the ZX81 during **LOAD** or **SAVE**. |
| **CLEAR** | deletes all variables. |
| **CONT** | restarts a program after **BREAK**, **STOP** or a screen full error. |
| **FAST** | changes the ZX81 to **FAST** mode (4×**SLOW**) in which the screen is blank while the screen is working. This is the only mode possible with ZX80. |
| **GOTO** n | starts running the program at line n, without deleting any variables. |
| **LET** | defines a variable. |
| **LOAD** s | sends a program titled s from tape into ZX81 memory, deleting any existing program. |
| **NEW** | deletes the existing program plus variables in ZX81 memory. |
| **POKE** m,n | puts the value n (Ø to 255) into the memory address m. |
| **PRINT** | prints on the screen whatever follows the **PRINT** command. |
| **RUN** | deletes all variables and starts the program at the first line. |
| **RUN** n | deletes all variables and starts the program at line n. |

| | |
|---|---|
| **SAVE** s | sends a program titled s from the ZX81 memory onto tape for long term storage. |
| **SLOW** | changes the ZX81 from **FAST** mode to **SLOW**, in which the ZX81 displays all its output while it is working. This is the mode obtained when the ZX81 is switched on, but is not possible on the ZX80. |
| **STOP** | gets the ZX81 out of an **INPUT** loop when typed as **INPUT**. Quotes must be rubbed out first in a string **INPUT** loop. |

## Program Statements

Keyword instructions which form part of the program. Although the ZX81 will accept any keyword in this way, **CONT** and **NEW** do not often make sense.

| | |
|---|---|
| **CLEAR** | deletes all variables. |
| **CLS** | clears the screen. |
| **DIM** A(n) | sets up a single-dimension numeric array A(1), A(2), . . . A(n) and sets each member to Ø. |
| **DIM** A($n_1$, $n_2$, . . . $n_k$) | sets up a multi-dimension numeric array and sets each member to Ø. |
| **DIM** B$ (n,m) | sets up a single-dimension array of strings, each having a maximum of m characters, B$ (1), B$(2), . . . B$(n) and sets each member to a string of m spaces. |
| **DIM** B$ ($n_1$, $n_2$, . . . $n_k$, m) | sets up a multi-dimension array of strings containing a maximum of m characters each, and sets each member to a string of m spaces. |
| **FAST** | changes the ZX81 to **FAST** mode (see command **FAST**). |
| **FOR** J=n **TO** m<br>. . .<br>**NEXT** J | sets up a **FOR** . . . **NEXT** loop. J is set initially at n, and increased by 1 after each circuit. When J>m the loop is ended and the main program continues. The loop is entered n−m+1 times (once only if m<n), and the final value of J is m+1. |
| **FOR** J=n **TO** m **STEP** p | modifies the **FOR** . . . **NEXT** loop so that J is increased by p after each circuit. If required p may be negative, with m<n. |

| | |
|---|---|
| **GOSUB** n | jumps to a subroutine at line n, continues from there until **RETURN** is reached, then jumps back to the line following **GOSUB** n. |
| **GOTO** n | jumps to line n of the program and continues from there. |
| **IF** condition/ **THEN** statement | conditional statement, **IF** the condition is met **THEN** the statement (any keyword) is executed. If the condition is not met, the program continues at the line following. |
| **INPUT** | stops the program so that the user can input a value to a numeric or string variable. |
| **LET** | assigns a value to a numeric or a string variable. |
| **PAUSE** n | stops the program and displays any output for n/5Ø seconds, or until any key is pressed. If n>32767 the pause lasts indefinitely until any key is pressed. |
| **PLOT** m,n | Blacks in a single pixel (¼ character) on the screen at the position 'm along and n up'. m=Ø to 63 and n=Ø to 43 inclusive. The next **PRINT** position is immediately after this pixel. |
| **POKE** m,n | puts the value n (Ø to 255) into the memory address m. |
| **PRINT** | prints whatever follows **PRINT** (number, numeric or string variable, expression, literal string) at the current **PRINT** position on the screen. |
| **PRINT AT** m,n; | prints whatever follows **PRINT**, at a position m lines down and n characters along, regardless of the current **PRINT** position. |
| **PRINT TAB** n; | moves the **PRINT** position to the n th character on the current line (or on the next line if the present **PRINT** position>n), and whatever follows **PRINT** is printed there. |
| **PRINT** s (m **TO** n) | prints part of the string s, from the m th to the n th character. If m or n is omitted, then the first or last character is assumed. |

| | |
|---|---|
| **RAND** | sets a random number as a seed for future **RND** expressions. |
| **REM** | indicates a remark, to be ignored by the ZX81. |
| **RETURN** | see **GOSUB.** |
| **RUN** and **RUN** n | deletes all variables and restarts the program at the beginning or at line n. |
| **SCROLL** | moves the screen contents up one line, and sets the **PRINT** position at the beginning of the bottom line. |
| **STEP** | see **FOR** . . . **NEXT** . . . **STEP** |
| **SLOW** | changes the ZX81 to **SLOW** mode (see command **SLOW**). |
| **STOP** | stops the program, and any output up to that point is displayed. Command **CONT** restarts program. |
| **UNPLOT** m,n | exactly like **PLOT**, except that **UNPLOT** un-blacks a single pixel on the screen. |

## Commands/Statements for use With Printer

| | |
|---|---|
| **COPY** | prints a copy of the screen display. |
| **LLIST** | prints a list of the current program. |
| **LLIST** n | prints a list of the current program, starting at line n. |
| **LPRINT** | prints whatever follows **LPRINT.** |

## Numeric Functions

| | |
|---|---|
| **ABS** n | the absolute value of n (with sign removed). |
| **ARCCOS** n | the angle (in radians) which has the cosine n. |
| **ARCSIN** n | the angle (in radians) which has the sine n. |
| **ARCTAN** n | the angle (in radians) which has the tangent n. |
| **COS** n | the cosine of n (angle in radians). |
| **EXP** n | $e^n$ (the natural antilog of n). |
| **INT** n | the integer part of n. |
| **LN** n | the natural log of n (base e). |
| **PEEK** n | the value currently stored at memory address n. |
| **PI** (or π) | 3.14159 . . . |
| **RND** | a pseudo-random number between Ø and 1. |
| **SGN** n | the sign portion of n. If n positive **SGN** n = 1, if n = Ø **SGN** n = Ø, if n negative **SGN** n = −1. |

| | |
|---|---|
| **SIN** n | the sine of n (angle in radians). |
| **SQR** n | the square root of n. |
| **TAN** n | the tangent of n (angle in radians). |
| **USR** n | calls the machine code subroutine at address n. |

## String-Handling Functions

| | |
|---|---|
| **CHR$** n | the character which has the code n (n between Ø and 255 inclusive). |
| **CODE** s | the code number of the first character of s. |
| **INKEY$** | reads the whole keyboard. **INKEY$** is a single character corresponding to a key pressed, or the null string if no key is pressed. |
| **LEN** s | the length (number of characters) of the string s. |
| **STR$** n | converts the number n to an apparently identical string 'n'. |
| **VAL** s | converts the string s, if possible, to a number or an expression which is evaluated as a number. |

## Logical Operators

**NOT**
**AND** used with **IF** in conditional statements.
**OR**

## Arithmetic Operators

| | |
|---|---|
| n**m | n raised to the power of m. |
| −n | negatives the value of n. |
| n*m | n times m. |
| n/m | n divided by m. |
| n+m | n plus m. |
| n−m | n minus m. |

## Relational Operators

Used to compare two numbers, variables or expressions. = is also used with **LET** to assign a value to a variable.

| | |
|---|---|
| n=m | n equals m. |
| n<m | n is less than m. |

| | |
|---|---|
| n>m | n is greater than m. |
| n<=m | n is less than or equal to m. |
| n>=m | n is greater than or equal to m. |
| n<>m | n is not equal to m. |

**NOT** can be used with any of these, e.g. **NOT** n=m is the same as n<>m.

## Punctuation

| | |
|---|---|
| ; | instruction to print the next **PRINT** item immediately following the item before; |
| , | instruction to move to the beginning of the next **PRINT** zone, and print the next item there. Each line on the screen is divided into two equal **PRINT** zones. |
| " | marks the beginning and end of a literal string or a string **INPUT**, or for defining a string variable. |
| . | used as a decimal point. |
| "" | a picture of a quotation mark for use inside strings. |
| ( ) | used to change the priority in a numerical expression or a logical statement. |

With the exception of " all the above (as well as : and ?), may be used inside strings.

# Appendix 2

## Glossary of Terms

**Address** The number which identifies a byte of memory.

**Back-up storage** Some method of long term storage of programs and variables, e.g. a cassette recorder.

**BASIC** Originally designed for beginners, now one of the most widely used high level languages for micro-computers.

**Binary digit (Bit)** One digit from a binary number; can only be Ø or 1.

**Binary number** A number in the binary system (base 2), where all the digits are Ø or 1, instead of Ø to 9 as in the decimal (base 1Ø) system.

**Bug** An error in a program which prevents it from doing what is required of it.

**Byte** A binary number 8 bits long, the normal storage unit in a microcomputer memory.

**Character** Any item which can be stored in one byte and printed on the screen, e.g. A 1 ; **PRINT** are all ZX81 characters.

**Character codes** The single byte number which identifies each character — these may vary from one computer to another.

**Command** An instruction which does not form part of the program, but which makes the computer take action of some kind.

**Concatenation** Joining two or more strings together like links in a chain.

**Conditional statement** A statement which is carried out only if a given condition is satisfied.

**Crash** The program stops running because of a program or data error.

**Debug** To find and remove errors from a program.

**Edit** To select and alter any chosen line in a program.

**Enter** To transfer a program line, or a command, or some data from the keyboard to the computer (by pressing **NEWLINE** on the ZX81).

**Empty string** A string containing no characters at all (also called a null string).

**Firmware** Sometimes used to denote the interpeter program, and other permanent programs found in ROM.

**Flowchart** A representation in diagrammatic form of a series of connected operations to be done in a specified sequence.

**Function** Some specified operation which is carried out on the number or string which follows.

**Hardware** The physical parts of a computer and the surrounding equipment, as opposed to programs.

**High level language** Programming language made up of a set of recognisable English words.

**Integer** A whole number which may be positive or negative.

**K (of memory)** A unit of memory containing 1024 bytes.

**Keyword** A command, statement or function occupying one byte of memory and entered by one or two keystrokes.

**Literal string** A set of characters enclosed by quotation marks and printed literally on the screen by the computer.

**Load** To transfer a program from back-up storage to the computer.

**Loop** Part of a program which is carried out repeatedly.

**Low level language** Programming language which uses machine code.

**Machine code** Programming code which uses the hexadecimal system to represent binary numbers.

**Nested loops** Loops within loops, so that the instructions in inner loops are carried out several times for each pass round the outer loop.

**Null string** See *Empty string.*

**Numeric array** A set of numeric variables each identified by an array name and subscript number(s).

**Numerical variable** A variable with some given name, to which can be assigned any desired number value or numerical expression.

**Pixel** Short for picture cell. The smallest graphics unit which can be printed on the screen. In the ZX81 system the screen is filled by 63 pixels across and 43 pixels up.

**Printer** Connected to a computer to allow it to produce its output in permanent form on paper.

**Priority** The order in which arithmetical or logical operations are carried out.

**Program** A numbered list of instructions to be carried out by a computer.

**Pseudo-random numbers** These have an apparently random distribution but each number is in fact calculated by the computer from the previous number, and they are therefore not truly random.

**Random access memory (RAM)**
Computer memory used by the programmer for storage of programs, data, and so on. Each byte of RAM can be read or altered at will.

**Random number** A number drawn from a given set, where each number in the set is equally likely to be drawn and the draw is not affected by previous events.

**Read only memory (ROM)** Permanent computer memory generally used to contain BASIC interpreter programs, operating systems and so on. Can be read but not changed.

**Relational operators** Symbols like =, <, >, used to compare numbers, expressions or strings.

**Report code** A signal from the ZX81 which is shown at the end of a successful run, or when the program is stopped by **BREAK, STOP** or an error.

**Save** To transfer a program into back-up storage for future use.

**Scientific notation** In which a number is displayed in terms of its mantissa (a number between Ø and 1Ø) and its exponent (the power of ten by which the mantissa is to be multiplied). The ZX81 uses this system for very large or very small numbers, which it would not have room to display otherwise.

**Software** Computer programs and manuals, as opposed to hardware.

**Statement** An instruction to the computer which forms part of the program.

**String array** A set of string variables identified by an array name and subscript number(s). In ZX81 BASIC, a string array contains one extra final dimension showing the length of each member.

**String variable** A variable, identified in BASIC by a name ending in the $ sign, to which may be assigned a string of characters of any kind (with minor exceptions).

**Subroutine** A part of the program to which the computer can be directed from any part of the main program. When the subroutine has been carried out, the computer is directed back to the line following its original departure point.

**Syntax error** Some error in the structure of a program line which prevents it from being executed, and in the case of the ZX81, from being entered into the program.

# Appendix 3

## Programs for the ZX81

1. Random rectangles (1K)
2. Square spiral (1K)
3. Random bar chart (1K)
4. Sales chart (1K)
5. Moving average (1K)
6. Multiples (1K)
7. Finding factors of numbers (1K)
8. Number base conversion (1K)
9. Drawing pictures (1K)

9a. Drawing pictures and storing them in an array (16K)

10. Cows and bulls (1K)
11. Electronic dice (1K)
12. Reaction timer (1K)
13. Black box (16K)
14. Telephone list (16K)

## 1. **Random Rectangles** (1K)

The program uses part of the screen (about 2/3) in which to draw an unlimited series of rectangles of random size and at random positions.

```
 1Ø  RAND
1ØØ  LET A=INT (RND*43)
11Ø  LET B=INT (RND*43)
12Ø  LET C=INT (RND*43)
13Ø  LET D=INT (RND*43)
14Ø  IF A=C THEN LET A=A+1
15Ø  IF B=D THEN LET B=B+1
2ØØ  FOR J=A TO C STEP SGN (C—A)
21Ø  PLOT J,B
22Ø  PLOT J,D
23Ø  NEXT J
24Ø  FOR J=B TO D STEP SGN (D—B)
25Ø  PLOT A,J
26Ø  PLOT C,J
27Ø  NEXT J
3ØØ  GOTO 1ØØ
```

*List of variables*

| | |
|---|---|
| A, B | coordinates of one corner of a rectangle. |
| C, D | coordinates of the opposite corner. |
| J | loop control variable. |

*Notes*

| | |
|---|---|
| Lines 1ØØ to 15Ø | set the corner coordinates to random Ø to 43, and make sure that A and C, B and D are not equal. |
| Lines 2ØØ to 23Ø | draw the horizontal sides. A may be larger or smaller than C, so we use **STEP SGN** (C−A), which may be +1 or −1, to make sure that the **FOR/NEXT** loop works properly. |
| Lines 24Ø to 27Ø | draw the vertical sides. |
| Line 3ØØ | goes back for the next rectangle. We do not need to include **RAND** in the loop — in certain programs this could produce the opposite effect to randomising. |

With 16K of RAM, you can let A and C go up to the full 63 which **PLOT** allows. You can easily change this program to draw a definite number of rectangles, or for use as a subroutine to draw a rectangle, given the coordinates of opposite corners.

## 2. **Square Spiral** (1K)

A useless but pretty program which alternately draws and then rubs out a square spiral in the middle of the screen. Perhaps you could modify it to draw a rectangular spiral which could be used in a program title.

```
  10 LET S=1000
  20 LET D=25
  30 LET H=5
  40 LET V=18
  50 LET S=3000-S
  90 IF D=1 THEN GOTO 20
 100 FOR H=H TO H+D
 110 GOSUB S
 120 NEXT H
 130 LET D=D-1
 200 FOR V=V TO V+D
 210 GOSUB S
 220 NEXT V
 230 LET D=D-1
 300 FOR H=H TO H-D STEP-1
 310 GOSUB S
 320 NEXT H
 330 LET D=D-1
 400 FOR V=V TO V-D STEP-1
 410 GOSUB S
 420 NEXT V
 430 LET D=D-1
 440 GOTO 90
1000 UNPLOT V,H
1010 RETURN
2000 PLOT V,H
2010 RETURN
```

*List of variables*

| | |
|---|---|
| S | flag to determine which subroutine is entered. |
| D | width of spiral. |
| H, V | coordinates of starting point. |

*Notes*

| | |
|---|---|
| Line 5Ø | sets the flag S to 2ØØØ or 1ØØØ in alternate passes of the loop. |
| Line 9Ø | checks for end of main loop, then goes back to re-set variables. |
| Lines 1ØØ to 12Ø | draws the first vertical line. |
| Line 13Ø | reduces the length of the side by one. |
| Lines 2ØØ to 23Ø | draws the next horizontal side. |
| Lines 23Ø to 43Ø | draw the remaining two sides. |
| Line 44Ø | goes back to line 9Ø to draw the next bit of the spiral. |
| Lines 1ØØØ to 2ØØØ | alternative subroutines to plot or unplot the spiral. |

## 3. **Random Bar Chart** (1K)

The program prints a set of fifty vertical bars of random height, and works out and prints the mean height of the fifty bars.

```
  5 LET T=Ø
 1Ø FOR J=Ø TO 49
 2Ø LET R=INT (RND*4Ø+1)
 3Ø LET T=T+R
 4Ø FOR K=Ø TO R
 5Ø PLOT J,K
 6Ø NEXT K
 7Ø NEXT J
 8Ø PAUSE 1ØØ
 9Ø FOR J=Ø TO 49
1ØØ PLOT J,T/5Ø
11Ø NEXT J
12Ø PRINT TAB 5;"MEAN R=";T/5Ø
```

*List of variables*

| | |
|---|---|
| T | total of the random numbers. |
| J,K | loop control variables. |
| R | a random number between 1 and 4Ø. |

*Notes*

Lines 1Ø to 3Ø   this part of the J loop generates fifty random

| | |
|---|---|
| | numbers between 1 and 4Ø and totals them. |
| Lines 4Ø to 6Ø | this K loop draws a vertical bar equal in height to the current random number R. |
| Lines 9Ø to 11Ø | plot a horizontal line as near as possible to the mean height of the fifty bars. |
| Line 12Ø | prints the mean of the fifty random numbers. |

## 4. **Sales Chart** (1K)

A demonstration bar chart showing sales of nuts and bolts during the past five years.

```
 1Ø  DIM S(5,2)
 1ØØ FOR J=1 TO 5
 11Ø FOR K=1 TO 2
 12Ø LET S(J,K)=INT (RND*11+1Ø)
 13Ø NEXT K
 14Ø NEXT J
 2ØØ PRINT "FIVE YEAR SALES FIGS","FOR NUTS ( ) AND
     BOLTS ( )",,,
 25Ø PRINT "YEAR",,
 3ØØ FOR J=1 TO 5
 3Ø5 PRINT 1976+J;" ";
 31Ø FOR K=1 TO 2Ø
 32Ø IF S(J,1)>=K AND S(J,2)>=K THEN PRINT "■";
 33Ø IF S(J,1)>=K AND S(J,2)<K THEN PRINT "▄";
 34Ø IF S(J,2)>=K AND S(J,1)<K THEN PRINT "▀";
 35Ø NEXT K
 36Ø PRINT
 37Ø PRINT
 38Ø NEXT J
 4ØØ PRINT"    Ø 2 4 6 8 1 1 1 1 1 2"    (4 spaces)
 41Ø PRINT"              Ø 2 4 6 8 Ø"    (14 spaces)
```

*List of variables*

| | |
|---|---|
| S(5,2) | 5×2 array of sales figures for two items during five years. |
| J,K | loop control variables. |

*Notes*

| | |
|---|---|
| Lines 1ØØ to 14Ø | generate a set of random sales figures in the range 1Ø to 2Ø. |

| | |
|---|---|
| Lines 3ØØ, and 36Ø to 38Ø | outside loop, dealing with the five years. |
| Lines 31Ø to 35Ø | print a bar on the chart for one year, with tests to determine which of the three possible graphic blocks is to be printed. |

## 5. **Moving Average** (1K)

The input to the program consists of a continuous series of figures, for instance monthly sales figures. The program takes the N most recent figures (you specify N), and calculates the mean and standard deviation.

```
 1Ø  LET K=Ø
 1ØØ PRINT "HOW MANY NOS.?"
 11Ø INPUT N
 12Ø DIM X(N)
 2ØØ LET K=K+1
 21Ø PRINT "NEXT NUMBER? ";
 22Ø INPUT X(K)
 23Ø PRINT X(K)
 24Ø IF K<NTHEN GOTO 2ØØ
 25Ø CLS
 3ØØ LET SX=Ø
 31Ø LET SS=Ø
 32Ø PRINT "LAST ";N;" NUMBERS",,,,
 33Ø FOR J=1 TO N
 34Ø LET SX=SX+X(J)
 35Ø LET SS=SS+X(J)**2
 36Ø PRINT "      ";X(J)
 37Ø IF J>1 THEN LET X(J-1)=X(J)
 38Ø NEXT J
 4ØØ PRINT,,"MEAN=";SX/N
 41Ø PRINT,,"STD DEV= ";SQR (SS/N-(SX/N)**2),,,,,
 42Ø GOTO 21Ø
```

*List of variables*

| | |
|---|---|
| K | subscript for the X(n) figure currently being input. |
| N | the number of figures to be averaged at a time. |
| X(N) | an array of N numbers. |
| SX | the sum of the last N numbers. |
| SS | the sum of the squares of the last N numbers. |

*Notes*

| | |
|---|---|
| Lines 1ØØ to 12Ø | inputs the number of figures to be averaged at a time, and dimensions X(N) accordingly. |
| Lines 2ØØ to 24Ø | **INPUT** loop for X(N). At the beginning, it is entered N times, after that only once for each new calculation. |
| Lines 33Ø to 38Ø | J loop which takes each of the X(N) numbers in order, and does these four things with them:<br>1 Sums them (SX).<br>2 Sums their squares (SS).<br>3 Prints them.<br>4 With the exception of X(1), drops each number down one place in the array, so that X(1) is lost, X(2) becomes X(1), X(3) becomes X(2), and so on. |
| Lines 4ØØ to 41Ø | calculate and print the mean and the standard deviation of the last N numbers. |
| Line 42Ø | goes back for a new X(N). |

Obviously this program can be simplified to calculate the mean and standard deviation of a single set of numbers.

## 6. **Multiples** (1K)

The program prints out a Ø to 99 number square, with the multiples of any given number printed in inverse.

```
 1Ø  PRINT "TYPE ANY NUMBER, Ø TO 99"
 2Ø  INPUT N
 3Ø  CLS
1ØØ  PRINT "THE MULTIPLES OF ";N;" ARE"
11Ø  IF N=Ø THEN LET N=1ØØ
2ØØ  FOR J=Ø TO 9
21Ø  FOR K=Ø TO 9
22Ø  IF J=Ø THEN PRINT " ";
23Ø  LET M=1Ø*J+K
24Ø  IF INT (M / N)*N=M THEN GOTO 5ØØ
25Ø  PRINT M;" ";
26Ø  NEXT K
27Ø  PRINT
28Ø  PRINT
29Ø  NEXT J
3ØØ  GOTO 1Ø
5ØØ  IF J>Ø THEN PRINT CHR$ (J+156);
51Ø  PRINT CHR$ (K+156);" ";
52Ø  GOTO 26Ø
```

*List of variables*

| | |
|---|---|
| N | chosen number for multiples. |
| J,K | loop control variables. |
| M | the current number in the number square. |

*Notes*

| | |
|---|---|
| Line 11Ø | changes N to 1ØØ if N=Ø, to avoid a dividing by zero error in line 24Ø. Ø is always printed in inverse since it is a multiple of every other number. |
| Line 23Ø | generates the current number in the square from J and K. |
| Line 24Ø | tests the current number to see if it is a multiple of N. |
| Line 25Ø | prints non-multiples normally. |
| Lines 5ØØ to 51Ø | print multiples of N in inverse by using the fact that the code of an inverse number is 156 more than the actual number. |

## 7. **Finding Factors of Numbers** (1K)

The first version of this program works by iteration — repeating the same operations over and over again. It takes a given number, divides it by two until that 'won't go', then divides by three, etc. If there are no factors apart from the number itself, it announces 'prime number'.

```
1ØØ PRINT "FACTORISING NUMBERS"
11Ø PRINT "WHATS YOUR NUMBER"
12Ø INPUT N
13Ø LET NN=N
14Ø LET F=2
17Ø PRINT ,,,,N;" =1";
2ØØ IF N / F<>INT (N / F) THEN GOTO 3ØØ
22Ø PRINT " X ";F;
23Ø LET N=N / F
25Ø GOTO 2ØØ
3ØØ IF N=1 THEN GOTO 4ØØ
33Ø LET F=F+1
34Ø GOTO 2ØØ
4ØØ IF F=NN THEN PRINT " PRIME NUMBER"
```

```
410 PRINT
420 PRINT ,,"THATS ALL"
430 PRINT AT 21,19;"PRESS NEWLINE"
440 INPUT A$
450 CLS
460 GOTO 100
```

*List of variables*

| | |
|---|---|
| N | number to be factorised. |
| NN | dummy variable. |
| F | the factor currently being tried. |
| A$ | input empty string to continue with another number N. |

*Notes*

| | |
|---|---|
| Line 130 | puts N into a dummy variable NN. |
| Line 140 | sets the factor to 2 to start with. |
| Line 200 | checks whether N is divisible by F. |
| Lines 230 to 250 | N is divisible by F, so N is divided by F, and then sent back to line 200 to try again. |
| Line 300 | checks whether N has been reduced to 1, in which case it is time to stop dividing by F. |
| Lines 330 to 340 | N is not divisible by F, so increase F by 1, then back to line 200 to try again. |
| Line 400 | if F is the same as NN when all possible factors have been tried, N must be a prime number. |

The program works well but is desperately slow — try putting in 1998 and then 1997. The reason is that we are trying a whole lot of impossible numbers as factors — for instance we can rule out all the even numbers after 2. Also, if we have a prime number, there is no point in trying to divide by any factor bigger than its square root. So, let's type in some more lines to deal with these two points.

```
150 LET S=SQR N
160 LET PF=0
200 IF N / F<>INT(N / F) OR NN=2 THEN GOTO 300
240 LET PF=1
300 IF PF=0 AND F>S OR N=1 THEN GOTO 400
310 IF F=2 THEN LET F=1
330 LET F=F+2
400 IF PF=0 THEN PRINT " X ";NN;" PRIME NUMBER"
```

It's better now, but there's still a long way to go, for instance try putting in 3994 (which is 2 times a large prime). You will learn a lot about programming, and also about numbers, if you try to improve on my effort, using a flowchart.

## 8. **Number Base Conversion** (1K)

This program converts numbers from base ten to base two, or vice versa.

```
10  LET B$="BASE 10 NO.="
20  LET C$="BASE 2 NO.="
50  PRINT "NUMBER BASE CONVERSION"
60  PRINT,,"CHANGING FROM WHICH BASE?","2 OR 10?"
70  INPUT T
80  CLS
90  IF T=2 THEN GOTO 600
110 PRINT
120 PRINT,,B$;
130 INPUT T
140 PRINT T,,C$;
160 FOR J=INT (LN T/LN 256*8) TO 0 STEP -1
170 IF 2**J>T THEN GOTO 210
180 LET T=T-2**J
190 PRINT "1";
200 GOTO 220
210 PRINT "0";
220 NEXT J
230 GOTO 110
600 LET T=0
610 PRINT
620 PRINT,,C$;
630 INPUT A$
640 PRINT A$
650 FOR J=0 TO LEN A$-1
660 LET T=T+VAL A$ (LEN A$-J)*2**J
670 NEXT J
680 PRINT B$;T
690 GOTO 600
```

*List of variables*

B$, C$ strings used more than once.

| | | |
|---|---|---|
| T | 1 | choice of base to convert from. |
| | 2 | base 1Ø number to be converted. |
| | 3 | result of converting a base 2 number. |
| A$ | | Base 2 number to be converted. |

*Notes*

| | |
|---|---|
| Line 9Ø | program branches according to choice of base. |
| Line 16Ø | sets the J loop to start at the correct number of places for the base 2 number. |
| Line 17Ø | checks whether the current digit should be Ø or 1. |
| Lines 18Ø to 19Ø | if 1, removes the current power of 2 from T, and prints "1". |
| Line 21Ø | otherwise, prints "Ø". |
| Lines 65Ø to 67Ø | takes the digits of the base 2 number, one by one, multiplies them by the current power of 2, and sums them as T. |

T has been used for three different variables to save memory — this is allowable because T is redefined in all three places. There are other ways of converting between different number bases. Try to work out other methods, and different bases — hexadecimal is an important one.

## 9. **Drawing Pictures** (1K and 16K)

The 1K program will allow you to use about 2/3 of the screen to draw pictures on, with the drawing pixel under control of the four arrows at 5, 6, 7, 8 on keyboard. If you press D (for draw), the pixel leaves a continuous trail wherever it goes. If you press R (for rubout) it leaves no trail, and rubs out any previous drawing over which it passes.

```
 1Ø  LET X=Ø
 2Ø  LET Y=1Ø
 3Ø  LET F$="R"
1ØØ  IF INKEY$="R" THEN LET F$=INKEY$
11Ø  IF INKEY$="D" THEN LET F$=INKEY$
19Ø  IF F$="R" THEN UNPLOT X,Y
2ØØ  IF INKEY$="5" THEN LET X=X-1
21Ø  IF INKEY$="6" THEN LET Y=Y-1
22Ø  IF INKEY$="7" THEN LET Y=Y+1
23Ø  IF INKEY$="8" THEN LET X=X+1
3ØØ  IF X>5Ø THEN LET X=5Ø
31Ø  IF X<Ø THEN LET X=Ø
```

```
320 IF Y>43 THEN LET Y=43
330 IF Y<10 THEN LET Y=10
340 PLOT X,Y
400 GOTO 100
```

*List of variables*

| | |
|---|---|
| X,Y | coordinates of the present PLOT/UNPLOT point. |
| F$ | flag for 'draws' or 'rubout'. |

*Notes*

| | |
|---|---|
| Lines 100 to 400 | main loop in which all inputs are by **INKEY$**. |
| Lines 100 to 110 | set flag F$ for 'draw' or 'rubout'. |
| Line 190 | **UNPLOT** activated only in 'rubout' mode. |
| Lines 200 to 230 | **PLOT** point changed by the four cursor arrow keys. |
| Lines 300 to 330 | keep the **PLOT** position within a fixed rectangle. |

In the 16K program the drawing space has been reduced to a smaller rectangle, but otherwise the first part of the program works just as above. When you have completed your drawing, press Z, and the contents of the drawing rectangle are found by **PEEK** and put into an array. Now, by **GOTO** 2000, the drawing is repeated at any desired position on the screen. If desired, the array can be saved with lines 2000 to 2060 for future use.

Type the following lines in addition to those of the 1K program:

```
  40 DIM A(80)
 300 IF X>19 THEN LET X=19
 330 IF Y<28 THEN LET Y=28
 350 IF INKEY$="Z" THEN GOTO 1000
1000 LET F=PEEK 16396+256*PEEK 16397
1020 FOR J=0 TO 7
1030 FOR K=1 TO 10
1040 LET A(10*J+K)=PEEK (F+K+33*J)
1050 NEXT K
1060 NEXT J
1070 STOP
2000 PRINT AT 5,10;
2010 FOR J=0 TO 7
2020 FOR K=1 TO 10
2030 PRINT CHR$ A(10*J+K);
2040 NEXT K
2050 PRINT TAB 10;
2060 NEXT J
```

*List of variables*

| | |
|---|---|
| F | the byte which starts the display file. |
| J,K | loop control variables. |
| A(80) | the set of code numbers representing the contents of the drawing space. |

*Notes*

| | |
|---|---|
| Line 350 | sets flag to leave the main loop. |
| Line 1000 | finds the start of the display file. |
| Lines 1020 to 1060 | determine the code numbers corresponding to the contents of the drawing rectangle, and puts them into the array A(80). |
| Line 2000, line 2050 | set the new printing position for the picture. |
| Lines 2010 to 2060 | repeats the contents of the drawing rectangle in the new position. |

## 10. **Cows and Bulls** (1K)

A simple version of the old game, started in Exercise 25.1. The ZX81 generates a four digit number — digits between 1 and 6, and may be the same — and you have nine tries to guess it. After each guess, black blobs tell you the number of bulls scored (right digit in the right position), and grey blobs the number of cows (right digit but wrong position).

```
  20  DIM N(4)
 100  FOR J=1 TO 4
 110  LET N(J)=INT (RND*6+1)
 120  NEXT J
 200  FOR X=1 TO 9
 210  PRINT "GUESS NO ";X;"?";
 220  INPUT G$
 230  PRINT G$
 300  FOR J=1 TO 4
 310  IF G$(J)=STR$ N(J) THEN GOSUB 1000
 320  NEXT J
 330  FOR J=1 TO 4
 340  FOR K=1 TO 4
 350  IF G$(K)=STR$ N(J) THEN GOSUB 1100
 360  NEXT K
 370  LET N(J)=ABS N(J)
 380  NEXT J
```

```
 39Ø  PRINT
 4ØØ  NEXT X
 9ØØ  STOP
1ØØØ  PRINT "■";
1Ø1Ø  LET G$(J)=" "
1Ø2Ø  GOTO 112Ø
11ØØ  PRINT "▨";
111Ø  LET G$(K)=" "
112Ø  LET N(J)=-N(J)
113Ø  RETURN
```

*List of variables*

| | |
|---|---|
| N(4) | four random digits between 1 and 6. |
| X,J,K | loop control variables. |
| G$ | player's current guess at the hidden number. |

*Notes*

| | |
|---|---|
| Lines 1ØØ to 12Ø | generate the hidden four digit number. |
| Lines 3ØØ to 32Ø | test the four digits of the current guess for bulls. |
| Lines 33Ø to 38Ø | test as above for cows. |
| Line 37Ø | restores the digits of the hidden number ready for the next guess. |
| Lines 1ØØØ to 113Ø | subroutine dealing with cow and bull scoring. It is entered at different points for cow or bull score, but there is a common ending and return. |
| Lines 1Ø1Ø and 111Ø | cancel the current digit of the guess, when it has resulted in a cow or bull score. |
| Line 112Ø | cancels the current digit of the hidden number when it has been the subject of a cow or bull score. |

## 11. **Electronic Dice** (1K)

This program generates pseudo-random numbers from 1 to 6, and converts them into pictures of an actual dice face.

```
 1Ø  RAND
1ØØ  FOR J=1 TO 9
12Ø  PRINT AT J+6,1Ø;"█████████"     (9 inverse spaces)
14Ø  NEXT J
```

```
200  LET D=INT (RND*6+1)
210  GOSUB 1000+D*100
220  INPUT A$
230  CLS
240  GOTO 100
1100 PRINT AT 11,14;" "      (1 space)
1110 IF D=1 THEN RETURN
1200 PRINT AT 8,11;" "       (1 space)
1210 PRINT AT 14,17;" "      (1 space)
1220 RETURN
1300 GOTO 1100
1400 PRINT AT 8,11;"█"       (1 space, 5 inverse spaces,
                               1 space)
1410 PRINT AT 14,11;"█"      (as 1400)
1420 RETURN
1500 PRINT AT 11,14;" "      (1 space)
1510 GOTO 1400
1600 PRINT AT 8,11;" █"      (1 space, 2 inverse spaces,
                  1 space, 2 inverse spaces, 1 space)
1610 PRINT AT 14,11;"█"      (as 1600)
1620 RETURN
```

*List of variables*

| | |
|---|---|
| J | loop control variable. |
| D | pseudo-random number between 1 and 6. |
| A$ | empty string input to throw the dice again. |

*Notes*

| | |
|---|---|
| Lines 100 to 140 | draw the dice square. |
| Lines 200 to 210 | generate a random number D, and direct the ZX81 to the corresponding subroutine. |
| Lines 1100 to 1620 | six subroutines for printing spots on the dice. Rather an untidy lot of **GOTO**s and **RETURN**s, but it is meant to minimise the use of RAM. |

## 12. **Reaction Timer** (1K)

Follow the instructions, and this program will measure your reaction time and print it on a scale running from 0 to 60. The absolute accuracy is not very high, but it is consistent!

```
  9Ø  PRINT AT Ø,Ø;" HOW FAST DO YOU REACT ?      "
 1ØØ  PRINT "  PRESS ANY KEY                  "
 11Ø  PRINT "      WHEN THE SCREEN CLEARS  "
      (three lines above use inverse spaces and letters)
 16Ø  PRINT AT 11,1;
 17Ø  FAST
 19Ø  PAUSE RND*3ØØ+2ØØ
 21Ø  FOR A=Ø TO 62
 22Ø  IF INKEY$<>"" THEN GOTO 47Ø
 23Ø  PRINT "█";        (graphic block SHIFT 5)
 24Ø  PRINT "";         (empty string)
 25Ø  NEXT A
 46Ø  IF A=63 THEN PRINT "S L O W " (inverse letters)
 47Ø  IF A=Ø THEN PRINT "CHEAT"  (inverse letters)
 475  SLOW
 49Ø  PRINT
 5ØØ  FOR J=Ø TO 12
 51Ø  PRINT TAB J*5;J*5;
 52Ø  NEXT J
 53Ø  PRINT TAB 9;"MILLISECS"
 54Ø  PRINT,,TAB 5;"25 IS ABOUT AVERAGE"
 55Ø  PAUSE 2ØØ
 56Ø  CLS
 57Ø  GOTO 9Ø
```

*List of variables*

A,J loop control variables.

*Notes*

| | |
|---|---|
| Lines 9Ø to 11Ø | print a bold black heading. |
| Lines 17Ø to 19Ø | sets **FAST** mode, then after a random pause, the screen clears (ZX81 working in fast mode). |
| Lines 22Ø to 25Ø | timing loop, taking about 1 millisecond per pass. Line 22Ø jumps out of the timing loop when any key is pressed. |
| Line 47Ø | checks for cheating — key pressed before start of timing loop. |
| Lines 475 to 54Ø | back into **SLOW** mode and print scale. |

## 13. **Black Box** (16K)

Waddingtons produce an excellent board game called *Black Box*, and here is a version of this for the ZX81. The board consists of an eight by eight square, numbered from 1 to 32 round the perimeter. Four atoms are hidden inside the square, and you have to find them by shooting laser beams into the box from the various numbered positions. If you hit an atom, the beam is absorbed (shown by *). If there is an atom in the line next to your beam, the beam bounces off it, and eventually emerges from the box as shown by flashing letters. In the absence of atoms in its vicinity, the beam goes straight through the box. Warning — the beam can bounce off more than one atom in its passage through the box. If the beam finds atoms in the lines on both sides of the beam it is reflected straight back (shown by ▨). A reflection is also shown if there is an atom at the edge of the board next to your entry point.

You can guess where the atoms are, one by one, but be careful — there is a three shot penalty for a wrong guess. If you give up, the ZX81 will show you where the atoms were.

The rules are hard to explain, but you'll get the hang of them quickly. This is an original program — there are other versions around but I venture to hope that my graphics are better than most.

```
   5  RAND
  1Ø  DIM A(1Ø,1Ø)
  2Ø  LET S=37
  3Ø  LET B$="         "      (9 spaces)
  4Ø  LET NS=Ø
  5Ø  LET RG=Ø
 1ØØ  FOR J=Ø TO 11
 11Ø  PRINT AT J+5,9;"████████████"      (12 inverse spaces)
 12Ø  NEXT J
 13Ø  PRINT AT 1Ø,1Ø;"BLACK BOX"      (inverse letters)
 18Ø  PRINT AT 21,2Ø;"PLEASE WAIT"
 19Ø  PAUSE 2ØØ
 2ØØ  FAST
 2Ø5  CLS
 21Ø  GOSUB 1ØØØ
 215  SLOW
 22Ø  GOSUB 12ØØ
 23Ø  GOSUB 33ØØ
 25Ø  PRINT AT Ø,22;"WHAT NOW?";TAB 23;" ";TAB 23;
     """S""=SHOOT"; TAB 23;" ";TAB 23;"""G""=GUESS
     ";TAB 24;" ";TAB 24;" ";TAB 24;"""E""=END"
 27Ø  GOSUB 42ØØ
 28Ø  GOSUB 33ØØ
```

```
285  IF I$="G" THEN GOTO 3600
290  IF I$="S" THEN GOTO 305
295  IF I$="E" THEN GOTO 1300
300  GOTO 250
305  LET NS=NS+1
310  PRINT AT 10,25;"SHOT";TAB 26;"NO.";NS
420  LET S=S+1
430  LET S$=CHR$ S
490  PRINT AT 0,21;"WHAT NUMBER";TAB 23;"ARE YOU";
     TAB 24;"SHOOTING";TAB 26;"FROM?"
500  INPUT N
510  IF N<9 THEN GOSUB 1400
520  IF N>8 AND N<17 THEN GOSUB 2300
530  IF N>16 AND N<25 THEN GOSUB 2000
540  IF N>24 AND N<33 THEN GOSUB 1700
550  IF N>32 THEN GOTO 500
560  GOTO 240
990  STOP
1000 REM**DRAWING THE BOX
1010 PRINT AT 3,0;
1020 FOR J=1 TO 16
1030 PRINT "   ████████████████"     (3 spaces, 16 inverse spaces)
1040 NEXT J
1060 FOR J=1 TO 8
1070 PRINT AT 0,2+2*J;J
1080 PRINT AT 1+2*J,21;J+8
1090 PRINT AT 20,4;"2 2 2 2 2 1 1 1"
1095 PRINT AT 21,4;"4 3 2 1 0 9 8 7"
1100 PRINT AT 19-2*J,0;J+24
1110 NEXT J
1120 FOR J=6 TO 38 STEP 4
1130 FOR K=6 TO 38
1140 UNPLOT J,K
1150 UNPLOT K,J
1160 NEXT K
1170 NEXT J
1180 RETURN
1200 REM**PLACING FOUR ATOMS
1210 FOR J=1 TO 4
1220 LET X=INT (RND*8+2)
1230 LET Y=INT (RND*8+2)
1240 IF A(X,Y)=1 THEN GOTO 1220
1250 LET A(X,Y)=1
1260 NEXT J
1270 RETURN
```

```
1300  REM**PRINTING 4 ATOMS
1310  FOR X=2 TO 9
1320  FOR Y=2 TO 9
1330  IF A(X,Y)=1 THEN PRINT AT 21-2*Y,2*X;"*"
      (inverse *)
1340  NEXT Y
1350  NEXT X
1360  GOTO 3900
1400  REM**MOVING SOUTH
1410  LET X=N+1
1420  LET Y=10
1430  LET L=2
1440  LET C=2+2*(X-1)
1450  PRINT AT L,C;S$
1460  FOR J=1 TO 30
1470  NEXT J
1475  IF A(X,9)=1 THEN GOTO 3000
1480  IF A(X-1,Y-1)=1 OR A(X+1,Y-1)=1 THEN GOTO
      2600
1490  IF A(X+1,Y-1)=1 AND A(X-1,Y-1)=1 THEN GOTO
      2600
1500  IF A(X+1,Y-1)=1 THEN GOTO 2390
1510  IF A(X-1,Y-1)=1 THEN GOTO 1790
1520  IF A(X,Y-1)=1 THEN GOTO 3000
1530  IF Y=2 THEN GOTO 1560
1540  LET Y=Y-1
1550  GOTO 1490
1560  LET L1=19
1570  LET C1=2+2*(X-1)
1580  GOTO 4000
1700  REM**MOVING EAST
1710  LET X=1
1720  LET Y=N-23
1730  LET L=19-2*(Y-1)
1740  LET C=2
1750  PRINT AT L,C;S$
1760  FOR J=1 TO 30
1770  NEXT J
1775  IF A(2,Y)=1 THEN GOTO 3000
1780  IF A(X+1,Y+1)=1 OR A(X+1,Y-1)=1 THEN GOTO
      2600
1790  IF A(X+1,Y+1)=1 AND A(X+1,Y-1)=1 THEN GOTO
      2600
1800  IF A(X+1,Y-1)=1 THEN GOTO 2090
1810  IF A(X+1,Y+1)=1 THEN GOTO 1490
```

```
1820  IF A(X+1,Y)=1 THEN GOTO 3000
1830  IF X=9 THEN GOTO 1860
1840  LET X=X+1
1850  GOTO 1790
1860  LET L1=19-2*(Y-1)
1870  LET C1=19
1880  GOTO 4000
2000  REM**MOVING NORTH
2010  LET X=26-N
2020  LET Y=1
2030  LET L=19
2040  LET C=2+2*(X-1)
2050  PRINT AT L,C;S$
2060  FOR J=1 TO 30
2070  NEXT J
2075  IF A(X,2)=1 THEN GOTO 3000
2080  IF A(X-1,Y+1)=1 OR A(X+1,Y+1)=1 THEN GOTO
      2600
2090  IF A(X+1,Y+1)=1 AND A(X-1,Y+1)=1 THEN GOTO
      2600
2100  IF A(X+1,Y+1)=1 THEN GOTO 2390
2110  IF A(X-1,Y+1)=1 THEN GOTO 1790
2120  IF A(X,Y+1)=1 THEN GOTO 3000
2130  IF Y=9 THEN GOTO 2160
2140  LET Y=Y+1
2150  GOTO 2090
2160  LET L1=2
2170  LET C1=2+2*(X-1)
2180  GOTO 4000
2300  REM**MOVING WEST
2310  LET X=10
2320  LET Y=18-N
2330  LET L=19-2*(Y-1)
2340  LET C=19
2350  PRINT AT L,C;S$
2360  FOR J=1 TO 30
2370  NEXT J
2375  IF A(9,Y)=1 THEN GOTO 3000
2380  IF A(X-1,Y+1)=1 OR A(X-1,Y-1)=1 THEN GOTO
      2600
2390  IF A(X-1,Y+1)=1 AND A(X-1,Y-1)=1 THEN GOTO
      2600
2400  IF A(X-1,Y+1)=1 THEN GOTO 1490
2410  IF A(X-1,Y-1)=1 THEN GOTO 2090
2420  IF A(X-1,Y)=1 THEN GOTO 3000
```

```
243Ø  IF X=2 THEN GOTO 246Ø
244Ø  LET X=X−1
245Ø  GOTO 239Ø
246Ø  LET L1=19−2*(Y−1)
247Ø  LET C1=2
248Ø  GOTO 4ØØØ
26ØØ  REM**REFLECTION
26Ø5  FOR J=1 TO 1Ø
261Ø  PRINT AT L,C;" "      (1 space)
262Ø  FOR K=1 TO 2
263Ø  NEXT K
264Ø  PRINT AT L,C;"▨"      (1 GRAPHICS SHIFT A)
265Ø  FOR K=1 TO 3
266Ø  NEXT K
267Ø  NEXT J
268Ø  RETURN
3ØØØ  REM**ABSORPTION
3Ø1Ø  FOR J=1 TO 1Ø
3Ø2Ø  PRINT AT L,C;" "      (1 space)
3Ø3Ø  FOR K=1 TO 2
3Ø4Ø  NEXT K
3Ø5Ø  PRINT AT L,C;"*"
3Ø6Ø  FOR K=1 TO 3
3Ø7Ø  NEXT K
3Ø8Ø  NEXT J
3Ø9Ø  RETURN
33ØØ  REM**CLEARING TOP RIGHT SCREEN
331Ø  PRINT AT Ø,21;"  "      (2 spaces)
332Ø  FOR J=Ø TO 21
333Ø  PRINT AT J,23;B$
334Ø  NEXT J
335Ø  RETURN
36ØØ  REM**GUESSING AN ATOM
361Ø  PRINT AT Ø,23;"WHERE IS"; TAB 23;"THE ATOM? "
362Ø  PAUSE 2ØØ
363Ø  PRINT AT 3,24;"SQUARES";TAB 24;"ALONG? "
3635  GOSUB 42ØØ
364Ø  LET X=VAL I$
3645  IF X>8 THEN GOTO 3635
365Ø  PRINT X
366Ø  PAUSE 5Ø
367Ø  PRINT AT 6,25;"SQUARES";TAB 27;"UP? ";
3675  GOSUB 42ØØ
368Ø  LET Y=VAL I$
3685  IF Y>8 THEN GOTO 3675
```

```
369Ø  PRINT Y
37ØØ  IF A(X+1,Y+1)=1 THEN GOTO 38ØØ
371Ø  PRINT AT 21-2*(Y+1),2*(X+1);"0"      (inverse 0)
372Ø  PRINT AT 9,25;"NO ATOM";TAB 26;"THERE"
373Ø  PAUSE 2ØØ
374Ø  PRINT AT 12,24;"PENALTY";TAB 25;"3 SHOTS"
375Ø  LET NS=NS+3
376Ø  PAUSE 2ØØ
377Ø  GOTO 24Ø
38ØØ  PRINT AT 21-2*(Y+1),2*(X+1);"*"      (inverse *)
381Ø  PRINT AT 10,23;"WELL DONE";TAB 24;"GOT ONE"
382Ø  PAUSE 3ØØ
383Ø  LET RG= RG+1
384Ø  IF RG=4 THEN GOTO 43ØØ
385Ø  GOTO 24Ø
39ØØ  REM**SIGNING OFF
392Ø  PRINT AT 2Ø,24;"PRESS";TAB 24;"NEWLINE"
3925  INPUT C$
393Ø  CLS
394Ø  PRINT AT 5,Ø;"I HOPE YOU ENJOYED THE GAME",,
      TAB 1Ø;"PLAY AGAIN SOME TIME"
395Ø  STOP
4ØØØ  REM**FLASHING LETTERS
4Ø1Ø  FOR J=1 TO 1Ø
4Ø2Ø  PRINT AT L,C;" "      (1 space)
4Ø3Ø  PRINT AT L1,C1;" "      (1 space)
4Ø6Ø  PRINT AT L,C;S$
4Ø7Ø  PRINT AT L1,C1;S$
4Ø8Ø  FOR K=1 TO 3
4Ø9Ø  NEXT K
41ØØ  NEXT J
411Ø  RETURN
42ØØ  REM*GETTING AN INKEY$
421Ø  IF INKEY$<>"" THEN GOTO 421Ø
422Ø  IF INKEY$="" THEN GOTO 422Ø
423Ø  LET I$=INKEY$
424Ø  RETURN
43ØØ  REM**CONGRATS
431Ø  GOSUB 33ØØ
432Ø  PRINT AT Ø,24;"YOU GOT";TAB 24;"THE LOT"
433Ø  PAUSE 1ØØ
434Ø  PRINT AT 3,24;"WITH THE";TAB 25;NS;"TH";TAB 26;
      "SHOT"
435Ø  PAUSE 3ØØ
4360  PRINT AT 8,26;"PLAY";TAB 25;"AGAIN?";TAB 25;" ";
```

```
      TAB 25;"Y/N ?"
4370  INPUT C$
4380  IF C$="Y" THEN RUN
4390  IF C$="N" THEN GOTO 3930
4400  GOTO 4370
```

*List of variables*

| | |
|---|---|
| A(10,10) | the 64 squares in the black box, plus an invisible line of squares all round the perimeter. |
| B$ | a string of 9 spaces. |
| NS | the number of the current shot. |
| RG | the number of right guesses so far. |
| J,K | loop control variables. |
| I$ | the current value of INKEY$. |
| S$ | the current character indicating the beam in/beam out positions. |
| S | the code of this current character. |
| X,Y | grid coordinates. |
| L,C | line and column for printing character showing beam in. |
| L1,C1 | line and column for printing character showing beam out. |
| C$ | input string to make program continue. |

*List of subroutines*

| | |
|---|---|
| 1000 | draws the grid with surrounding numbers. |
| 1200 | places the four atoms in the grid at random. |
| 1300 | prints the four atoms on the grid when player gives up. |
| 1400 | deals with beams moving south. |
| 1700 | deals with beams moving east. |
| 2000 | deals with beams moving north. |
| 2300 | deals with beams moving west. |
| 2600 | prints characters to show a reflection. |
| 3000 | prints characters to show an absorption. |
| 3300 | clears the top right part of the screen. |
| 3600 | asks player to guess the position of one atom, and checks whether guess is correct. |
| 3900 | end of game, signing off. |
| 4000 | flashes characters to show where beam has entered and left the box. |
| 4200 | puts the current value for **INKEY$** into **I$**. |
| 4300 | congratulations — player has guessed all four atoms. |

*Notes*

The vital core of the program is made up of the four 'moving' subroutines which are all very similar. These notes apply to the 'moving east' subroutine:

| | |
|---|---|
| Lines 171Ø to 172Ø | set the coordinates for the starting point of the beam. |
| Lines 173Ø to 174Ø | set the print position for the character showing the entry point of the beam. |
| Line 1775 | checks for an edge absorption. |
| Line 178Ø | checks for an edge reflection. |
| Line 179Ø | checks for an internal reflection. |
| Line 18ØØ | checks for an atom on the line below the entry point, which deflects the beam north. |
| Line 181Ø | checks for an atom on the line above the entry point, which deflects the beam south. |
| Line 182Ø | checks for an atom in the next square ahead, which gives an absorption. |
| Line 183Ø | checks whether the beam has gone right through the box. |
| Lines 184Ø to 185Ø | if the beam is still in the box, increases the X coordinate by one, and back to check everything once more. |
| Lines 186Ø to 188Ø | set the print position for the character showing the exit point of the beam, and off to 4ØØØ to flash the characters at entry and exit points. |

## 14. **Telephone List** (16K)

This is a domestic example of a database program. It is capable of holding a lot of numbered items of data in an array, in this case names and phone numbers up to a total of 20 characters per item. *The program must never be executed by the command RUN* — this would lose all the data you have put in. Always execute the program with **GOTO** 1Ø. You will then be offered the choice of listing the items, putting a new item in, finding one item, or rubbing out an item. In each of the last three operations, the ZX81 is using only the first three characters of the items, so that 'Find Norman' would also turn up Norton, North, Norden, etc.

You can alter the program to deal with any other information you want to store. You can change the number of items or their length, being limited to about 650 items of 20 characters in 16K of RAM.

```
1Ø    DIM N$(1ØØ,2Ø)
```

```
20    LET N$(100) = "END"
30    LET E$ = "                    "    (20 spaces)
100   CLS
110   PRINT "PHONE NUMBER LIST",,,,,"ORDERS
      PLEASE?",,,,"LIST ALL THE NAMES = L","PUT NEW
      NAME/NUMBER IN = N","FIND A NUMBER = F",,
      "RUB OUT A NAME/NUMBER = R"
120   INPUT Z$
130   IF Z$ = "N" THEN GOTO 500
140   IF Z$ = "F" THEN GOTO 200
150   IF Z$ = "R" THEN GOTO 700
160   IF Z$ = "L" THEN GOTO 400
170   GOTO 120
200   CLS
205   PRINT,,,,"NAME PLEASE?"
210   INPUT Z$
215   IF LEN Z$<3 THEN GOTO 210
220   LET F = 0
230   LET X = 1
240   CLS
250   IF N$(X, TO 3)<>Z$( TO 3) THEN GOTO 300
260   LET F = 1
270   PRINT,,N$(X)
300   LET X = X + 1
310   IF N$(X, TO 3)<>"END" THEN GOTO 250
320   IF F = 0 THEN PRINT Z$;" NOT FOUND"
330   GOTO 1000
400   CLS
410   LET X = 0
420   LET X = X + 1
430   SCROLL
440   PRINT N$(X)
450   IF N$(X, TO 3)<>"END" THEN GOTO 420
460   SCROLL
470   GOTO 1000
500   CLS
510   LET X = 1
520   IF N$(X, TO 3) = "END" THEN GOTO 570
530   IF N$(X) = E$ THEN GOTO 600
540   LET X = X + 1
550   GOTO 520
570   PRINT,,"SORRY — NO MORE ROOM"
580   GOTO 1000
600   CLS
610   PRINT "NEW NAME/NUMBER?"
```

```
620   INPUT N$(X)
630   GOTO 100
700   CLS
710   PRINT "RUB OUT WHICH NAME ?"
720   INPUT Z$
730   LET X=1
735   IF N$(X, TO 3)="END" THEN GOTO 850
740   IF N$(X, TO 3)<>Z$( TO 3) THEN GOTO 900
745   CLS
750   PRINT N$(X)
760   PRINT "PRESS R TO RUB OUT",,,"OR NEWLINE FOR
      NEXT ";Z$( TO 3)
770   INPUT R$
780   IF R$<>"R" THEN GOTO 900
790   PRINT,,N$(X);" RUBBED OUT"
800   LET N$(X)=E$
810   GOTO 1000
850   CLS
860   PRINT,,"NO MORE ";Z$( TO 3);" NAMES IN THE
      LIST"
870   GOTO 1000
900   LET X=X+1
910   GOTO 735
1000  PRINT AT 21,13;"PRESS N/L FOR MORE"
1010  INPUT Z$
1020  GOTO 100
```

*List of variables*

| | |
|---|---|
| N$(100,20) | array of 100 strings of 20 characters each. |
| Z$,R$ | input string variables. |
| F | flag to indicate whether or not name found. |
| X | current subscript number. |

*Notes*

| | |
|---|---|
| Lines 100 to 170 | print a menu of four possible choices, with program branching in four different directions. |
| Lines 200 to 330 | routine for finding a name/number. Since only the first three letters have to match, this can turn up more than one name. |
| Lines 400 to 470 | produce scrolled list of all the 100 names in subscript order. |

| | |
|---|---|
| Lines 5ØØ to 63Ø | search for the first empty member of the array, and then allows the user to insert a new name. |
| Lines 7ØØ to 91Ø | routine for rubbing out an existing name. The user types in the name he wishes to rub out, and the program produces all the names corresponding (first three letters) one by one, with the option of deleting or going on to the next. |

# Appendix 4

## Sample Answers to Exercises

There are plenty of ways of writing a computer program. Do note that these are sample answers, and that they only use computer instructions learnt up to the chapter concerned. Your own solutions may be different but just as correct.

*Exercise 6.1. Line changing*

Type 15, **NEWLINE**,2Ø,**NEWLINE**, and then:

```
1Ø  PRINT "THREE LINES GONE, ONE LEFT"
```

*Exercise 6.2. Your address*

**NEW** deletes the old program.

```
1ØØØ  PRINT "MR. JOHN SMITH"
2ØØØ  PRINT " 23 HANLEY ROAD"
3ØØØ  PRINT "   STAFFORD"
4ØØØ  PRINT "     SD23 6MX"
```

*Exercise 7.1. Expressions with brackets*

```
(1) Stage 1  7-5=2        30 / 12=2.5
    Stage 2       2*2.5=5
    Stage 3       5**3=125 (answer)
(2) Stage 1  6*8=48        23-11=12
    Stage 2       48-12=36          5+7=12
    Stage 3           36 / 12=3
    Stage 4           3**2=9 (answer)
```

*Exercise 8.1. Money changing*

```
10  LET R=1.9
20  LET P=75
30  LET D=250
40  PRINT P*R
50  PRINT "US DOLLARS FOR "
60  PRINT P
70  PRINT "£"
100 PRINT
110 PRINT
120 PRINT D / R
130 PRINT "£ NEEDED TO GET "
140 PRINT D
150 PRINT "US DOLLARS"
```

*Exercise 8.2. Parachuting*

```
10  LET T=10
20  LET A=9.8
30  LET H=3000-A*T**2 / 2
40  PRINT "TIME= "
50  PRINT T
60  PRINT
70  PRINT "HEIGHT= "
80  PRINT H
```

The height is 2510 m after 10 seconds. If you put various times into line 10 you will find that after 22 seconds free fall the height is 628 m, that's the time to pull the ripcord.

*Exercise 9.1. Circles*

```
10  LET R=5
20  LET D=2*R
30  LET C=3.14*D
40  LET A=R**2*3.14
50  PRINT "    VITAL STATISTICS OF A CIRCLE"
60  PRINT
70  PRINT "IF THE RADIUS IS ";R;" CM"
80  PRINT
90  PRINT "DIAM= ";D;" CM","CIRCUMF= ";C;" CM"
100 PRINT TAB 8;"AREA= ";A;" SQ CM"
```

*Exercise 11.1. Decimal part*

```
10 LET N=17.59
20 PRINT "NUMBER";TAB 10;"INT";TAB 20;"DECIMAL"
30 PRINT
40 PRINT N;TAB 10;INT N;TAB 20;N-INT N
```

*Exercise 11.2. More rounding*

```
10 LET N=2.75
20 PRINT INT (N*10+.5) / 10
```

*Exercise 12.1. Building society interest*

```
 20 LET C=500
 30 LET Y=1982
100 PRINT Y;" CAPITAL+INTEREST=£";C
110 PRINT
120 LET Y=Y+1
130 LET C=C*1.08
140 IF Y<1990 THEN GOTO 100
```

Change line 100 as follows to round off to the nearest p.

```
100 PRINT Y;" CAPITAL+INTEREST=£";INT (C*100+.5) /
    100
```

*Exercise 12.2. When are the leap years?*

```
 10 LET Y=1982
100 PRINT "YEAR"
110 PRINT Y;
120 IF Y / 4=INT (Y / 4) THEN PRINT " LEAP YEAR";
130 LET Y=Y+1
140 PRINT
150 IF Y<2000 THEN GOTO 110
```

*Exercise 14.1. Percentages*

```
10 PRINT "YOUR MARK?";
20 INPUT M
30 PRINT M,,,,"MAX POSS MARK?"
```

```
40  INPUT MAX
50  CLS
60  PRINT M;" OUT OF ";MAX;"=";M/MAX*100;" PER
    CENT",,,
70  GOTO 10
```

*Exercise 14.2. Petrol consumption*

```
10  PRINT "HOW MANY MILES?";
20  INPUT M
30  PRINT M
40  PRINT "GALLONS USED?"
50  INPUT G
60  CLS
70  PRINT G;" GALL FOR ";M;" MILES= ";M / G;"
    MPG"
80  PRINT
90  GOTO 10
```

*Exercise 16.1. Table of square roots*

```
 10  PRINT "NUMBER","SQUARE ROOT"
 20  PRINT
100  FOR N=0 TO 16
110  PRINT N,SQR N
120  NEXT N
```

*Exercise 16.2. Multiples of four*

```
10  PRINT "MULTIPLES OF 4 UP TO 100"
20  FOR J=0 TO 100 STEP 4
30  PRINT TAB 2*J;J;
40  NEXT J
```

*Exercise 17.1. Multiplication square*

```
10  FOR J=1 TO 7
20  FOR K=1 TO 7
30  PRINT TAB 4*K;J*K;
40  NEXT K
50  PRINT,,,,
60  NEXT J
```

*Exercise 17.2. Rectangle*

```
1Ø  FOR J=1 TO 5
2Ø  FOR K=1 TO 19
3Ø  PRINT "■";
4Ø  NEXT K
5Ø  PRINT
6Ø  NEXT J
```

For a title, change line 1Ø to:

```
1Ø  FOR J=1 TO 4
```

and add:

```
6Ø  IF J=2 THEN PRINT " THIS IS A RECTANGLE" (inverse
    letters)
```

*Exercise 18.1. Form filling*

```
1Ø   PRINT "YOUR SURNAME PLEASE"
2Ø   INPUT S$
3Ø   PRINT,,"NOW YOUR FIRST NAME"
4Ø   INPUT F$
5Ø   PRINT ,, "AGE IN YEARS PLEASE"
6Ø   INPUT A$
7Ø   PRINT,,"AND WHERE DO YOU LIVE?"
8Ø   INPUT T$
9Ø   CLS
1ØØ  PRINT "THANK YOU VERY MUCH ";F$;"  ";S$
110  PRINT,,"YOU ARE ";A$;" YEARS OLD"
12Ø  PRINT " AND YOU LIVE IN ";T$
```

*Exercise 19.1. Choosing numbers*

```
1Ø   PRINT "TYPE A WHOLE NUMBER FROM 1 TO 99"
2Ø   PRINT "    THEN PRESS NEWLINE"
3Ø   INPUT N
4Ø   IF N<1 THEN GOTO 1ØØ
5Ø   IF N>99 THEN GOTO 1ØØ
6Ø   IF N<>INT N THEN GOTO 2ØØ
7Ø   GOTO 3ØØ
1ØØ  PRINT "NUMBER FROM 1 TO 99 PLEASE"
11Ø  GOTO 3Ø
2ØØ  PRINT "WHOLE NUMBERS PLEASE"
```

```
210  GOTO 3Ø
300  CLS
31Ø  PRINT "YOUR NUMBER IS ";N
32Ø  PRINT,,,,"ITS SQUARE IS ";N*N
33Ø  PRINT,,,,,,"NEXT NUMBER?"
34Ø  GOTO 3Ø
```

Note: At present you cannot guard against the user putting in letters — these give a 2/3Ø error. To cover this you need to know about the function **VAL** which comes later.

*Exercise 20.1. Roulette*

```
1ØØ  LET S=INT (RND*37)
11Ø  IF S<10 THEN PRINT " ";
12Ø  PRINT S;"  ";      (2 spaces)
13Ø  GOTO 1ØØ
```

Note: As written here the program includes a single zero, which I believe is the usual thing.

*Exercise 20.2. Random rectangles*

```
1ØØ  LET N=INT (RND*15+1)
2ØØ  FOR J=1 TO INT (RND*15+1)
21Ø  FOR K=1 N
22Ø  PRINT "▨";      (one GRAPHICS SHIFT A)
23Ø  NEXT K
24Ø  PRINT
25Ø  NEXT J
3ØØ  PAUSE 5Ø
31Ø  CLS
32Ø  GOTO 1ØØ
```

*Exercise 21.1. Water tank volumes*

```
 1Ø  LET V=Ø
11Ø  PRINT,,,,"WHAT SHAPE IS IT?"
12Ø  PRINT,,"CYLINDER — TYPE CYL"
13Ø  PRINT"  OR CUBE — TYPE CUBE"
14Ø  INPUT A$
15Ø  CLS
16Ø  IF A$="CYL" THEN GOSUB 1ØØØ
17Ø  IF A$="CUBE" THEN GOSUB 2ØØØ
```

```
180  IF V<>Ø THEN GOTO 3ØØ
190  PRINT "DONT KNOW ";A$;" SHAPE"
2ØØ  GOTO 14Ø
3ØØ  PRINT "VOL OF ";A$;" = ";V;" CUBIC CM"
9ØØ  STOP
1ØØØ REM**VOL OF CYL
1Ø1Ø PRINT "HEIGHT IN CM?";
1Ø2Ø INPUT H
1Ø3Ø PRINT H,,,,"DIAM IN CM? ";
1Ø4Ø INPUT D
1Ø5Ø PRINT D
1Ø6Ø LET V=PI*(D/2)**2*H
1Ø7Ø RETURN
2ØØØ REM*VOL OF CUBE
2Ø1Ø PRINT "EDGE LENGTH IN CM? ";
2Ø2Ø INPUT E
2Ø3Ø PRINT E
2Ø4Ø LET V=E**3
2Ø5Ø RETURN
```

Note: In line 18Ø we are using V as a flag to make the ZX81 by-pass lines 19Ø and 2ØØ if the volume has been calculated.

*Exercise 22.1. Number guessing*

```
2Ø   PRINT "WHATS MY CODE (1Ø TO 99)","YOU HAVE 8
     GUESSES",,,
1ØØ  LET C=INT (RND*9Ø+1Ø)
13Ø  FOR J=1 TO 8
14Ø  PRINT "GUESS ";J;"? ";
15Ø  LET G$=""
2ØØ  FOR K=1 TO 2
21Ø  IF INKEY$<> "" THEN GOTO 21Ø
22Ø  IF INKEY$= "" THEN GOTO 22Ø
23Ø  PRINT INKEY$;
24Ø  LET G$=G$+INKEY$
25Ø  NEXT K
31Ø  LET G=VAL G$
32Ø  IF G=C THEN GOTO 5ØØ
33Ø  IF G>C THEN GOTO 37Ø
34Ø  PRINT " IS TOO LOW"
35Ø  GOTO 4ØØ
37Ø  PRINT " IS TOO HIGH"
4ØØ  NEXT J
```

```
450 PRINT,,"IT WAS ";C
460 STOP
500 PRINT " IS RIGHT"
510 PRINT "GUESSED IT IN ";J" GOES"
```

Note: In line 15Ø we have to reset G$ to " ", the empty string, in order to get rid of the previous guess.

*Exercise 23.1. Vertical lines*

```
1ØØ FOR K=Ø TO 43
11Ø PLOT Ø,K
12Ø PLOT 63,K
13Ø NEXT K
```

Note: The program will not complete the verticals because of shortage of memory — you are trying to use too much screen. You must reduce the height from 43 to 37 to get a complete rectangle.

*Exercise 23.2. Visiting card*

```
 1Ø FOR J=12 TO 5Ø
 2Ø FOR K=16 TO 3Ø
 3Ø PLOT J,K
 4Ø NEXT K
 5Ø NEXT J
1ØØ PRINT AT 8,8;"JOHN JONES ESQ.,";TAB 9;"21
    OXFORD ROAD"; TAB 1Ø;"CHISWICK";TAB
    12;"W.4."       (all inverse letters)
```

Note: In line 1ØØ, **PRINT AT** 8,8 sets the print position on the first line, and then **TAB** is used to skip on to succeeding lines.

*Exercise 23.3. "On we go" subroutine*

```
 1ØØ PRINT "PAUSING NOW"
 11Ø GOSUB 1ØØØ
 12Ø PRINT AT 5,Ø;"GOING ON AGAIN"
 9ØØ STOP
1ØØØ REM**ON WE GO
1Ø1Ø PRINT AT 21,19;"PRESS NEWLINE"
1Ø2Ø INPUT A$
1Ø3Ø PRINT AT 21,19;"             "     (13 spaces)
1Ø4Ø RETURN
```

*Exercise 24.1. Ants*

```
 1Ø  LET L=5
 2Ø  LET C=Ø
 3Ø  PRINT "WHATS AN ANT?"
 4Ø  PAUSE 3ØØ
1ØØ  PRINT AT Ø,Ø;"TYPE A WORD                    "
     (32 letters plus spaces)
11Ø  INPUT W$
12Ø  IF LEN W$<3 THEN GOTO 2ØØ
13Ø  IF W$ (1 TO 3)="ANT" THEN GOTO 3ØØ
14Ø  IF W$ (LEN W$-2 TO LEN W$)="ANT" THEN GOTO
     3ØØ
2ØØ  PRINT AT Ø,Ø;W$;" IS NOT AN ANT"
21Ø  GOTO 4Ø
3ØØ  PRINT AT 3,5;"LIST OF ANTS"
31Ø  PRINT AT L,C;W$
32Ø  LET L=L+SGN C
33Ø  LET C=15-C
34Ø  GOTO 1ØØ
```

Notes: Line 12Ø rejects words of less than three letters.
Lines 13Ø and 14Ø accept words with ANT at the beginning or the end of the word.
Line 32Ø increases the **PRINT** line number by 1 on alternate loops.
Line 33Ø sets the **PRINT** column to Ø and 15 alternately.

*Exercise 25.1. Simple cows and bulls*

```
 1Ø  RAND
 2Ø  DIM N(4)
 3Ø  LET B=Ø
1ØØ  FOR J=1 TO 4
11Ø  LET N(J)=INT (RND*6+1)
12Ø  NEXT J
2ØØ  PRINT "GUESS MY NUMBER",,"FOUR DIGITS ALL
     BETWEEN 1 AND 6"
21Ø  INPUT A$
22Ø  CLS
23Ø  PRINT "YOUR GUESS WAS ";A$
3ØØ  FOR J=1 TO 4
31Ø  IF N(J)=VAL A$(J) THEN LET B=B+1
32Ø  NEXT J
4ØØ  PRINT,,,"YOU SCORED ";B;" BULLS"
```

Note: A program for the complete game is listed in Appendix 3, but maybe you would like to try your own hand at one first.

*Exercise 26.1. Test results*

```
 1Ø  DIM C$(6,6)
 2Ø  DIM M(6)
1ØØ  LET C$(1)="SIMON"
11Ø  LET C$(2)="MARINA"
12Ø  LET C$(3)="WILLIAM"
13Ø  LET C$(4)="EMILY"
14Ø  LET C$(5)="JAMES"
15Ø  LET C$(6)="JOANNE"
2ØØ  PRINT "NAME OF TEST?";
21Ø  INPUT T$
22Ø  PRINT T$,"MAX MARK?";
23Ø  INPUT M
24Ø  PRINT M
3ØØ  FOR J=1 TO 6
31Ø  PRINT C$(J),"MARK? ";
32Ø  INPUT M(J)
33Ø  PRINT M(J)
34Ø  NEXT J
4ØØ  CLS
41Ø  PRINT T$;" TEST",,,,
42Ø  PRINT "NAME","PER CENT",,,
43Ø  FOR J=1 TO 6
44Ø  PRINT C$(J),M(J)*1ØØ / M
45Ø  NEXT J
```

Note: Here we have two parallel single-dimension arrays, one for the names and one for the marks, in order to save memory. In a 16K program for a full class, one might use a two-dimension string array, input the marks as strings, and use **VAL** to turn them into numbers.

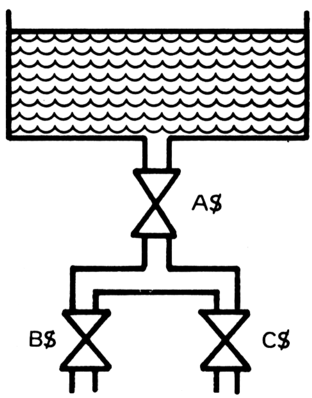
*Exercise 26.2. One-armed bandit*

```
 1Ø  RAND
 2Ø  DIM W$(6,6)
 3Ø  DIM N(3)
1ØØ  LET W$(1)=" BELL"
11Ø  LET W$(2)="LEMON"
12Ø  LET W$(3)="CROWN"
```

```
130  LET W$(4)="ANCHOR"
140  LET W$(5)="CHERRY"
150  LET W$(6)="APPLE"
200  FOR J=1 TO 3
210  LET N(J)=INT (RND*6+1)
220  PRINT AT 10,(J-1)*12;W$(N(J))
230  NEXT J
240  IF N(1)<>N(2) THEN GOTO 300
250  IF N(2)<>N(3) THEN GOTO 300
260  PRINT AT 18,15;"JACKPOT"
270  STOP
300  INPUT A$
310  GOTO 200
```

Note: Here we have a single-dimension array of six strings, and one of three random numbers. In line 220 we are using a member of the number array as the subscript to the string array variable. Lines 240-250 are not very elegant, we need logical **AND** which comes in the next chapter.

*Exercise 27.1. Water tank Mk.2*




Note: Water will only run out of the tank if tap A$ is open, as well as either tap B$ or tap C$.

*Exercise 28.1. Flasher*

```
 100  GOSUB 1000
 900  STOP
1000  REM**FLASHING WINNER
```

```
1Ø1Ø  FOR J=1 TO 1Ø
1Ø2Ø  PRINT AT 21,15;"      "      (6 spaces)
1Ø3Ø  FOR K=1 TO 1Ø
1Ø4Ø  NEXT K
1Ø5Ø  PRINT AT 21,15;" WINNER "    (inverse letters)
1Ø6Ø  FOR K=1 TO 2Ø
1Ø7Ø  NEXT K
1Ø8Ø  NEXT J
1Ø9Ø  RETURN
```

*Exercise 28.2. Rubber ball*

```
  1Ø  LET V=Ø
  2Ø  LET VV=1
 1ØØ  FOR J=2Ø TO 4Ø
 11Ø  PLOT J,1
 12Ø  NEXT J
 14Ø  FOR X=Ø TO 19
 15Ø  PRINT AT V,15;" "
 16Ø  LET V=V+VV
 17Ø  PRINT AT V,15;"0"
 18Ø  IF V=X OR V=2Ø THEN LET VV=-VV
 19Ø  IF V<>2Ø THEN GOTO 15Ø
 2ØØ  NEXT X
```

*Exercise 28.3. Lunar module*

```
 1ØØ  FOR L=Ø TO 18
 11Ø  PRINT AT L,15;"   ";TAB 14;" A ";TAB
      14;"<S>";TAB 14;"I I"
 12Ø  FOR K=Ø TO L*2
 13Ø  NEXT K
 14Ø  NEXT L
```

Note: All the strings making up the module are three characters long, and the 'S' in the middle should be inverse. The module is an unshamed steal from 'Lunar Landing', an excellent game — one of a series produced in cassette form by Sinclair ZX Software.

Lines 12Ø and 13Ø provide a steadily increasing pause in the main loop, to make the landing reasonably soft.

# Appendix 5

## The 16K RAM Pack

The main part of this book has been written for users of the Sinclair ZX81 (and generally for the ZX80 with BASIC in 8K ROM) with the standard 1K of RAM or user memory in which to put program, data, display file and so on. As your programming technique improves, you will soon find that you need more RAM than this. Sinclair Research Ltd. supply a neat expansion box which plugs into the edge connector at the back of the ZX81/ZX80 to provide a total of 16K of RAM. At a little more than two thirds of the cost of the assembled ZX81, it represents good value by today's standards.

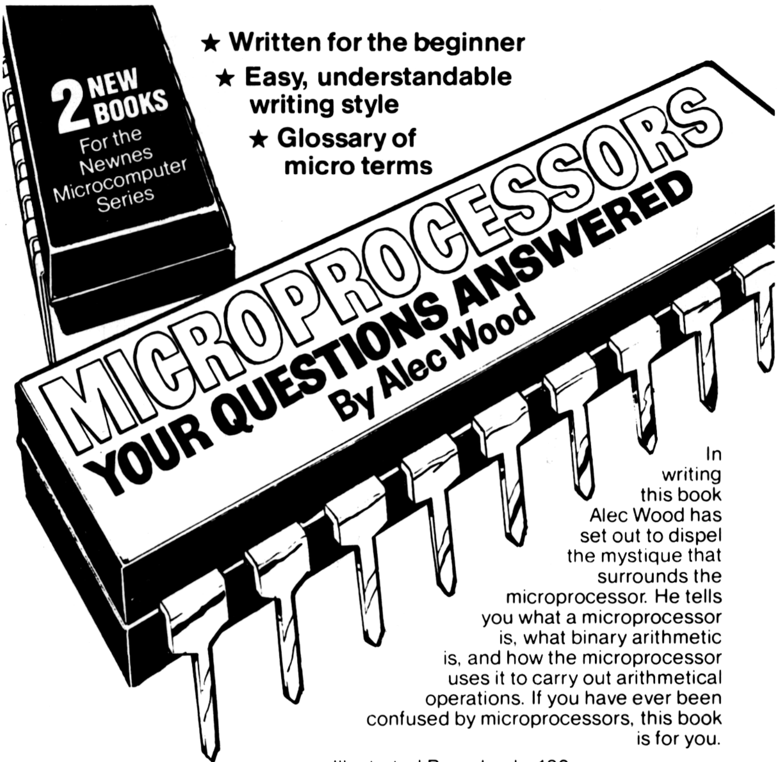
The expanded ZX81 can be used to write longer programs (such as Program 13 in Appendix 3). It can also be used to store more data, remembering that all data is saved on tape with your program, and can be loaded and used again later (Programs 9 and 14 in Appendix 3).

The 16K RAM Pack is no problem to use — simply plug it in *before* you switch on (never insert it or remove it while the ZX81 is switched on). Remember, even short programs saved with the 16K RAM Pack in place take up more tape space — it's best to plug in the Pack again when you want to load them later.


*The 16K RAM pack being inserted into the ZX81*

# Index

* Titles of exercises included in Chapters 6 to 28
** Titles of programs in Appendix 3

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